The status of extracting sin(2$\alpha_{(eff)}$) by BaBar

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- Introduction
- BaBar detector
- Status of $B^0 \rightarrow \pi^+\pi^-$ analysis
- Status of $B^0 \rightarrow \rho^+\pi^-$ analysis
- Conclusion

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The Cabibbo-Kobayashi-Maskawa Matrix

Mass eigenstates ≠ Flavor eigenstates ➜ Quark mixing

B and K mesons decay weakly

➜ modified couplings for charged weak currents:

$$V_{\mathrm{CKM}} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

V_{CKM} unitary and complex

➜ 4 real parameters (3 angles and 1 phase)

Kobayashi, Maskawa 1973

Wolfenstein Parameterization (expansion in $\lambda \sim 0.2$):

$$V_{CKM} \approx \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

CPV phase

The Unitarity Triangle

B sector:

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$

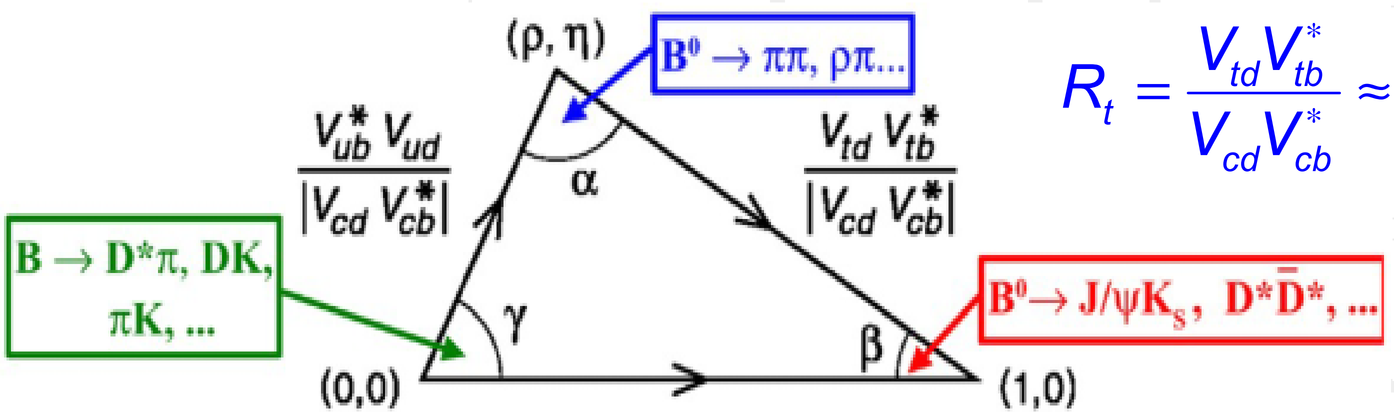
$$\propto A\lambda^3 \quad \propto -A\lambda^3 \quad \propto A\lambda^3$$

K sector:

$$V_{ud}V_{us}^* + V_{cd}V_{cs}^* + V_{td}V_{ts}^* = 0$$

$$\propto \lambda \quad \propto -\lambda \quad \propto -A^2\lambda^5$$

Expect large *CP*-violating effects in *B*-System



$$R_t = \frac{V_{td}V_{tb}^*}{V_{cd}V_{cb}^*} \approx -\sqrt{(1-\bar{\rho})^2 + \bar{\eta}^2}\, e^{-i\beta}$$

$$R_u = \frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*} \approx -\sqrt{\bar{\rho}^2 + \bar{\eta}^2}\, e^{i\gamma}$$

$$\gamma = \arg V_{ub}^* \ , \quad \alpha = \pi - \gamma - \beta$$

$B^0\bar{B}^0$ Mixing

Schrödinger equation governs time evolution of B^0-$\bar{B}^0$ System:

$$\boxed{i\frac{d}{dt}\begin{pmatrix} B^0 \\ \bar{B}^0 \end{pmatrix} = \left(M - \tfrac{i}{2}\Gamma\right)\begin{pmatrix} B^0 \\ \bar{B}^0 \end{pmatrix}}$$

with mass eigenstates:

$$\left|B_L\right\rangle \propto p\left|B^0\right\rangle + q\left|\bar{B}^0\right\rangle$$

$$\left|B_H\right\rangle \propto p\left|B^0\right\rangle - q\left|\bar{B}^0\right\rangle$$

Defining:

$$\Delta m_B \equiv M_H - M_L \approx 2\,|M_{12}|$$

$$\Delta\Gamma_B \equiv \Gamma_H - \Gamma_L \;= 2\mathrm{Re}\left(M_{12}\Gamma_{12}^{*}\right)/\,|M_{12}|$$

One obtains for the time-dependent asymmetry:

$$\boxed{A_{\text{mixing}}(\Delta t) = \frac{N(\text{unmixed}) - N(\text{mixed})}{N(\text{unmixed}) + N(\text{mixed})} = \cos\left(\Delta m_B \Delta t\right)}$$

where::

$$\text{unmixed}: \quad e^+e^- \to B^0(\Delta t)\bar{B}^0(\Delta t)$$

$$\text{mixed}: \quad e^+e^- \to B^0(\Delta t)B^0(\Delta t)$$

and: $\quad A_{\text{mixing}}(\Delta t = 0) = 1$

- measurement of mixing requires the knowledge of B-flavor – “tagging”

CP-violaton in the Standard Model

Three observable interference effects:

$$\left|\frac{q}{p}\right| = \left|\frac{1-\varepsilon_{B_d}}{1+\varepsilon_{B_d}}\right| \neq 1 \quad \Rightarrow \quad \mathrm{Prob}(B^0 \to \overline{B}^0) \neq \mathrm{Prob}(\overline{B}^0 \to B^0)$$

CP violation in mixing

-small in the B-system because $\Delta\Gamma \ll \Delta M$

-small in the K-system because relevant weak phase is tiny

- the only mechanism in "superweak" model

-observed for neutral Kaon decays

$$\left|\overline{A}_{\bar{f}} / A_f\right| \neq 1 \quad \Rightarrow \quad \mathrm{Prob}(\overline{B} \to \bar{f}) \neq \mathrm{Prob}(B \to f)$$

CP violation in decay

- requires interference between at least two amplitudes

amplitudes must have two phases, one that changes sign under CP (e.g. from CKM), and one that doesn't

(e.g. strong phase)

- hard to understand theoretically

- observed for neutral Kaons by E731, NA31, KTeV, NA48

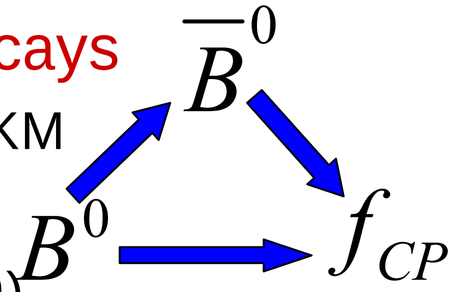
$$\mathrm{Re}(\varepsilon'/\varepsilon) = (17.2 \pm 1.8_{(\mathrm{stat+syst})}) \times 10^{-4}$$

CP-violaton in the Standard Model

CP violation in the interference of mixing and decays

- in decays dominated by single amplitude, extraction of CKM elements is clean

- observable in time evolution of B^0B^0 system (assume $\Delta\Gamma=0$)



$$f(\overline{B}^0_{phys} \to f_{CP}, \Delta t) = \tfrac{\Gamma}{4} e^{-\Gamma|\Delta t|}\left[1 + S_{f_{CP}} \sin(\Delta m_d \Delta t) - C_{f_{CP}} \cos(\Delta m_d \Delta t)\right]$$

$$f(B^0_{phys} \to f_{CP}, \Delta t) = \tfrac{\Gamma}{4} e^{-\Gamma|\Delta t|}\left[1 - S_{f_{CP}} \sin(\Delta m_d \Delta t) + C_{f_{CP}} \cos(\Delta m_d \Delta t)\right]$$

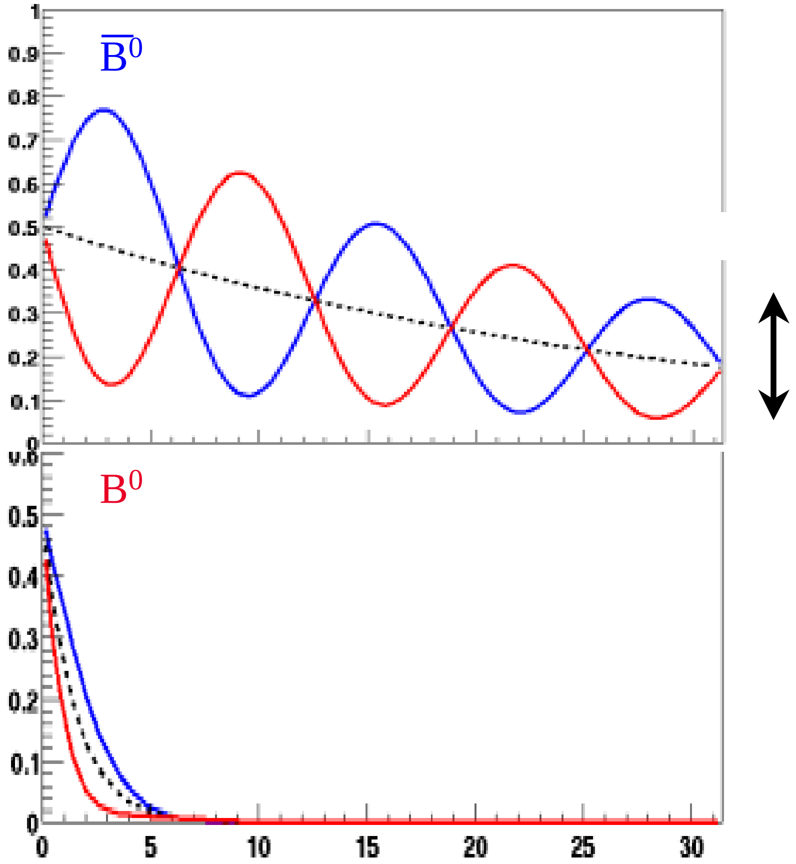
$$\lambda_{f_{CP}} = \frac{q}{p} \cdot \frac{\overline{A}_{f_{CP}}}{A_{f_{CP}}}$$

direct CP violation $\rightarrow$ C $\neq$ 0

indirect CP violation $\rightarrow$ S $\neq$ 0

$$S_f = \frac{2\,\mathrm{Im}\,\lambda_{f_{CP}}}{1 + |\lambda_{f_{CP}}|^2} \qquad C_f = \frac{1 - |\lambda_{f_{CP}}|^2}{1 + |\lambda_{f_{CP}}|^2}$$

Mixing in $B^0\ \overline{B}^0$ system



~ few

Ratio of oscillation frequency to decay rate:

In B decays, the oscillation frequency is small compared to the decay rate!

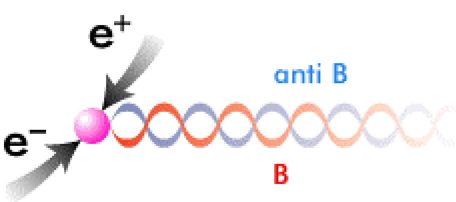
~ 0.1

SLAC

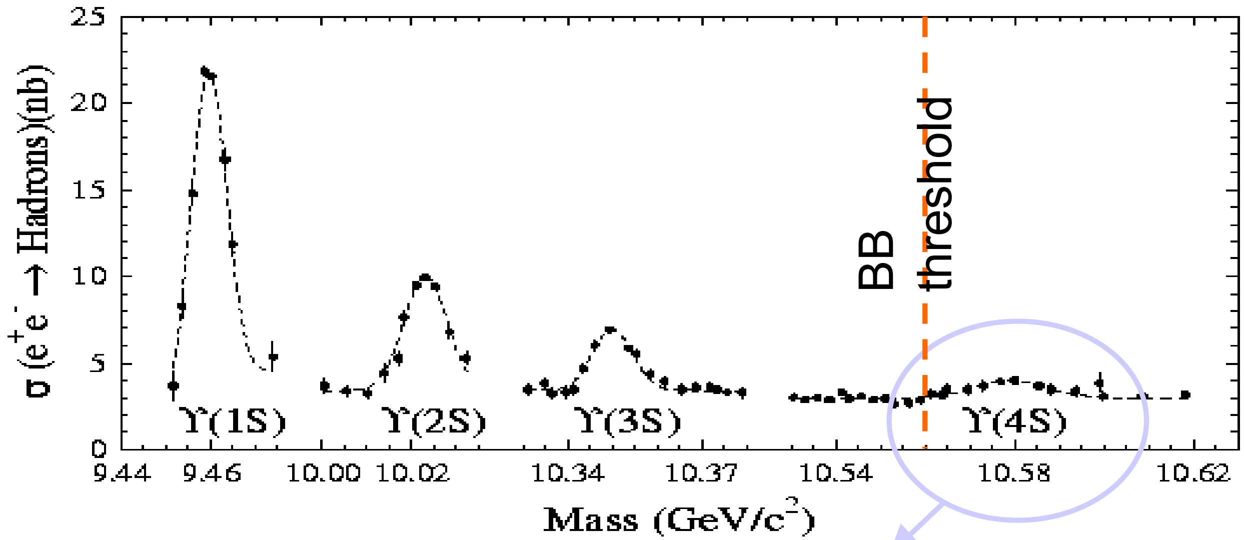
Stanford
Linear
Accelerator
Center

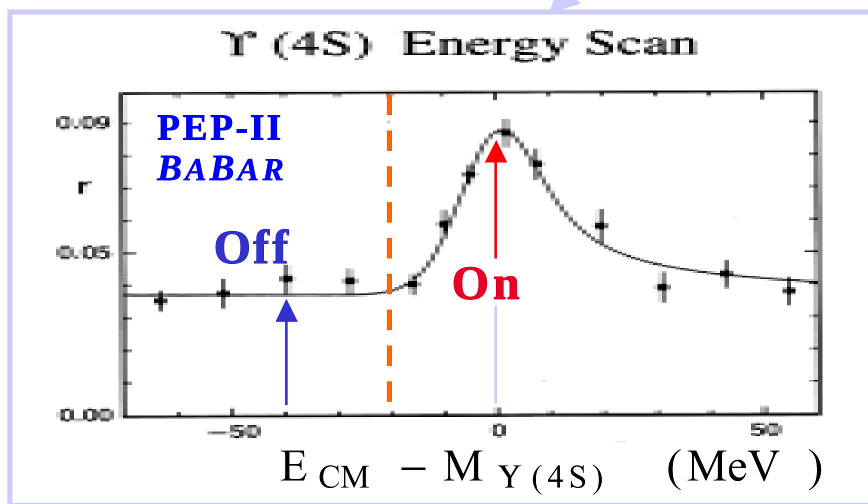
The Asymmetric *B*-Meson Factory PEP-II:

$$e^+e^- \rightarrow \Upsilon(4S) \rightarrow B\bar{B}$$



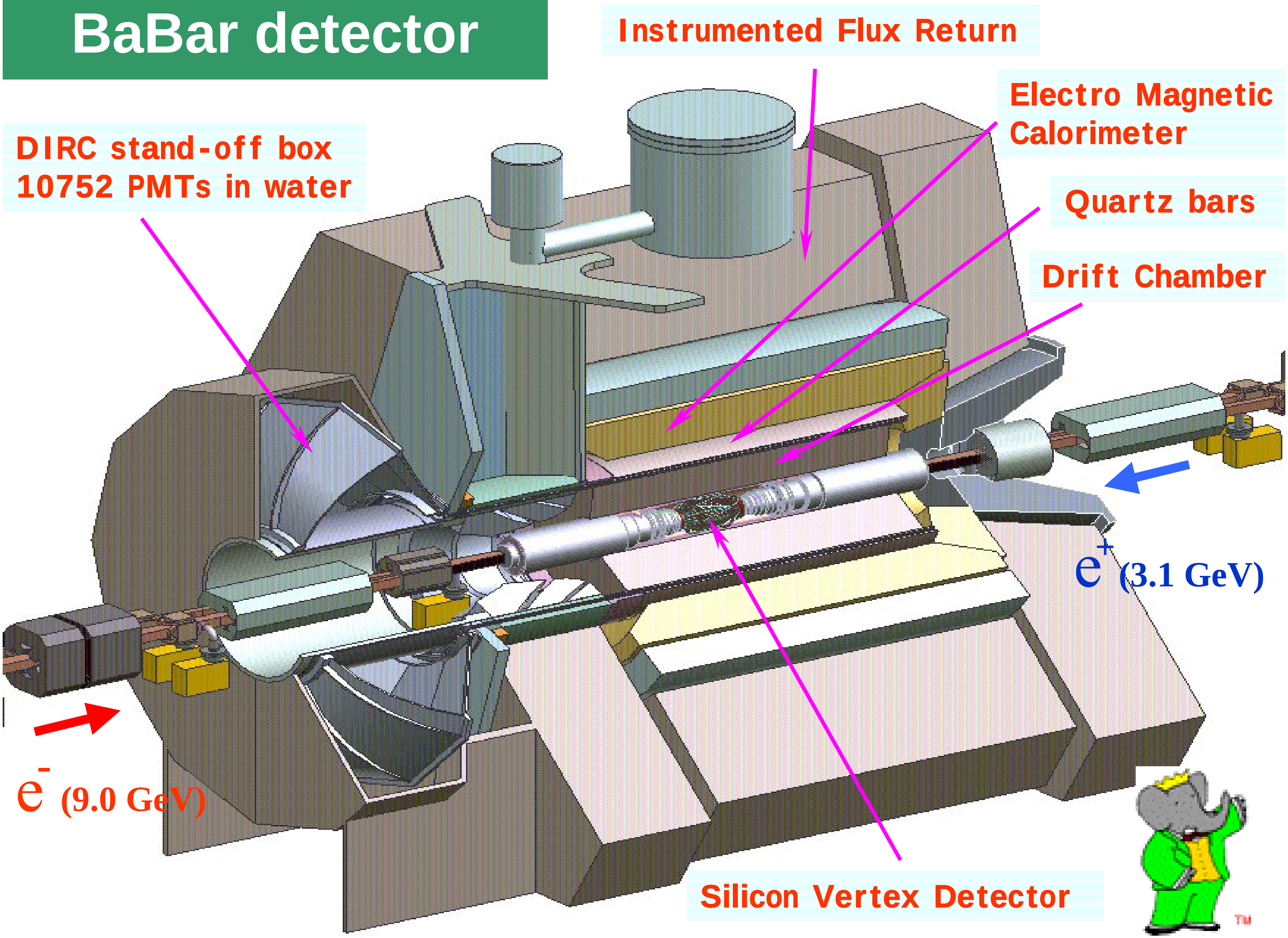
9 GeV e^- on 3.1 GeV e^+ :



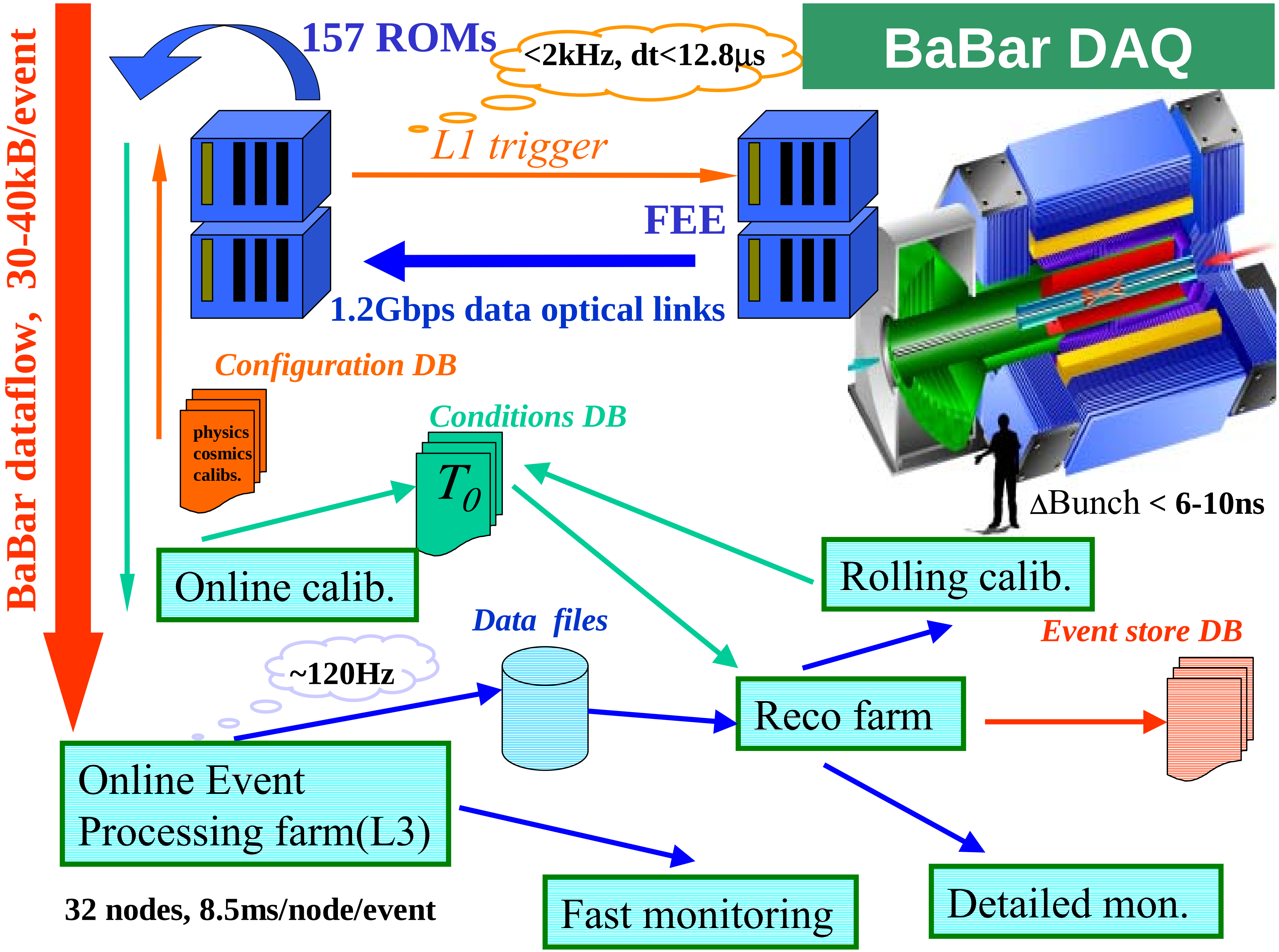


- coherent neutral *B* pair production and decay (p-wave)
- boost of $\Upsilon(4S)$ in lab frame : $\beta\gamma = 0.56$

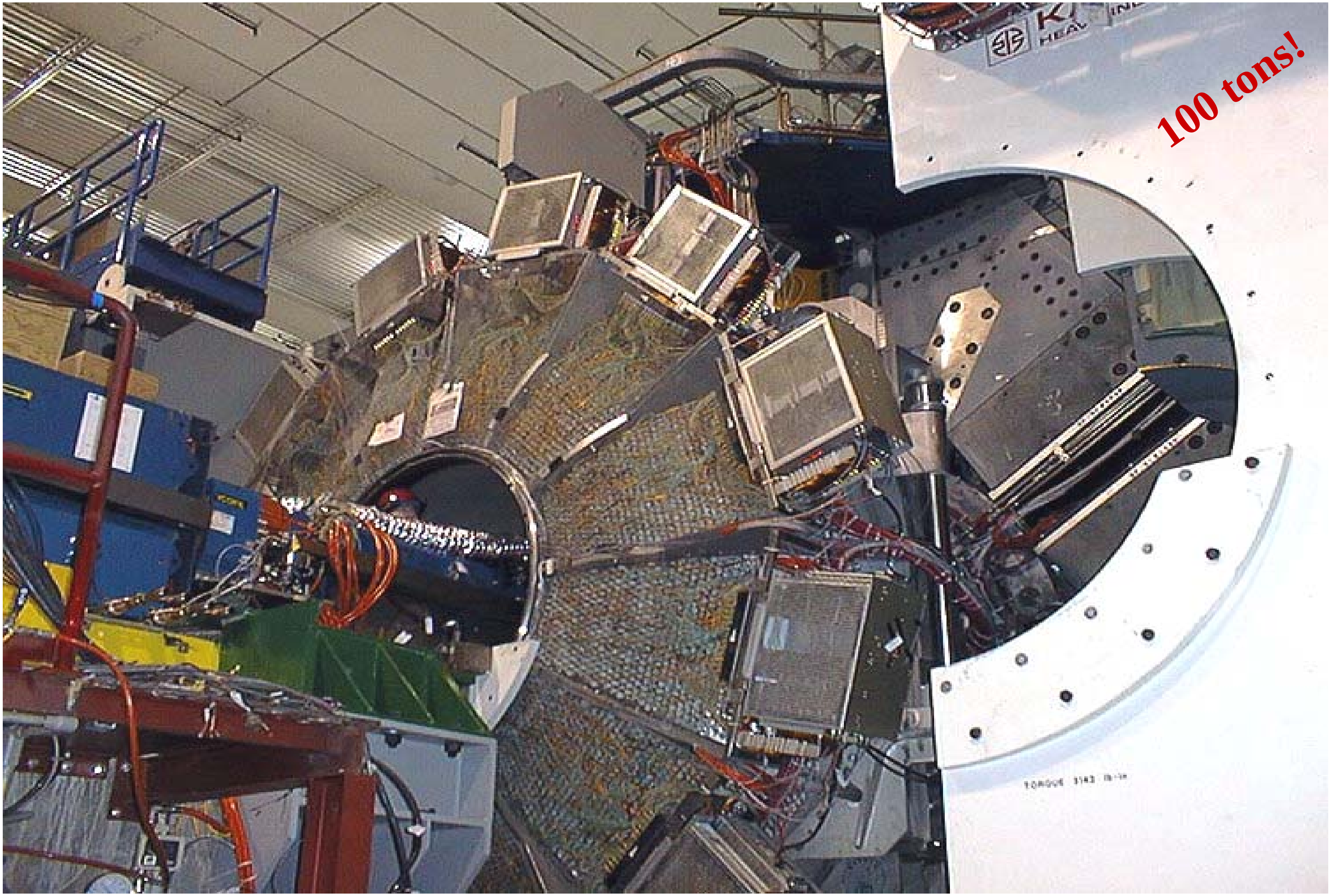
BaBar detector



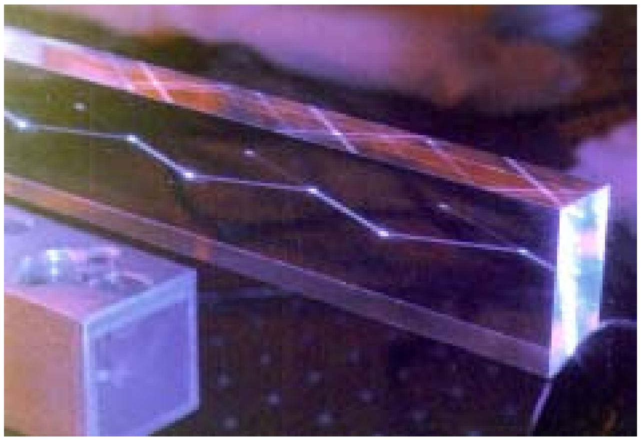
BaBar DAQ

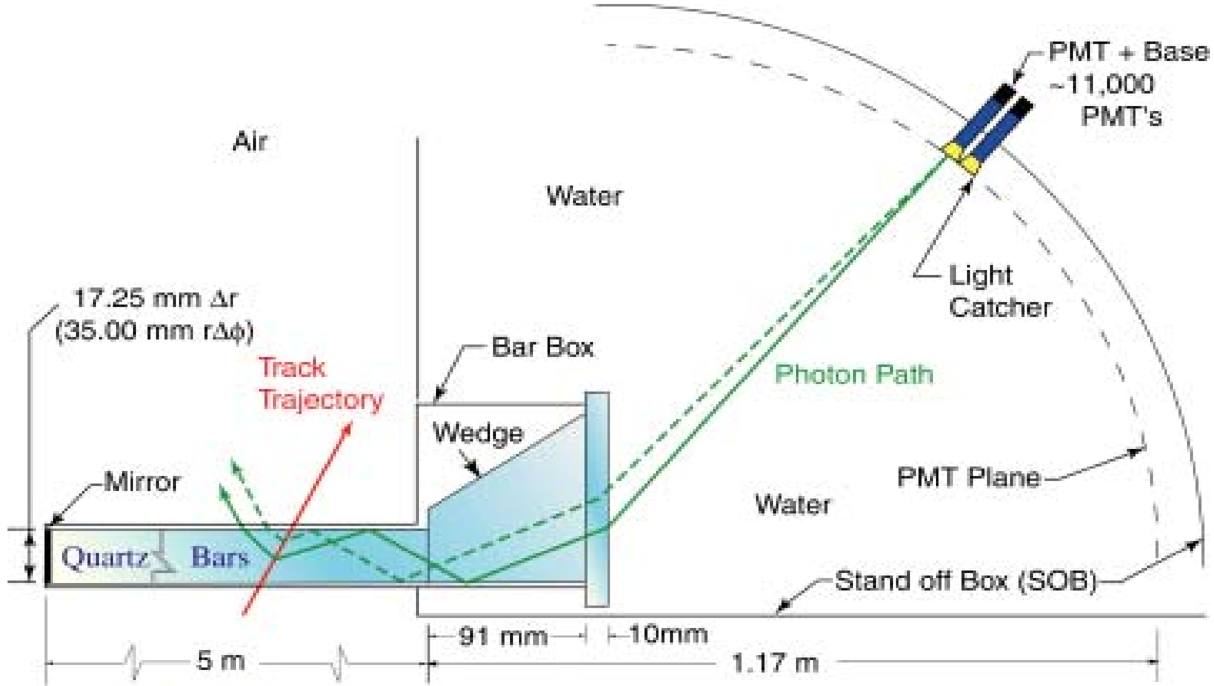

BaBar dataflow, 30-40kB/event
157 ROMs
<2kHz, dt<12.8μs
L1 trigger
FEE
1.2Gbps data optical links
Configuration DB
physics
cosmics
calibs.
Conditions DB
T_0
ΔBunch < 6-10ns
Online calib.
Rolling calib.
Data files
Event store DB
~120Hz
Reco farm
Online Event Processing farm(L3)
32 nodes, 8.5ms/node/event
Fast monitoring
Detailed mon.

DIRC with open doors

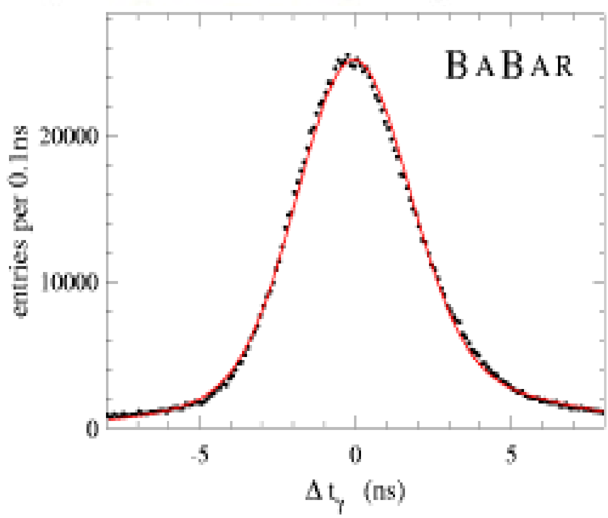


DIRC principle

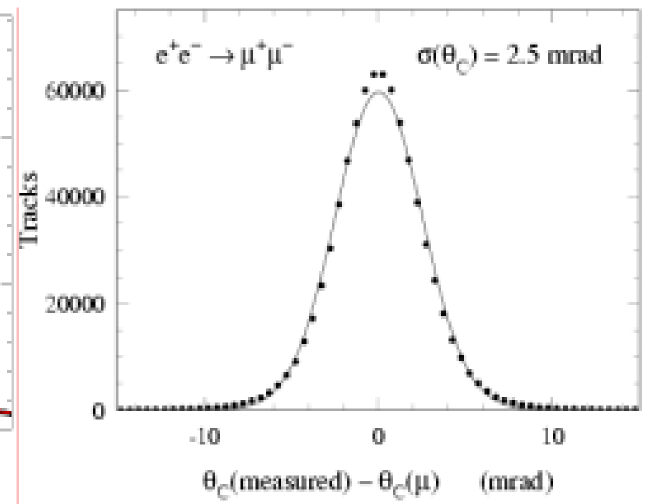




$$\cos\Theta_c = 1/n\beta$$

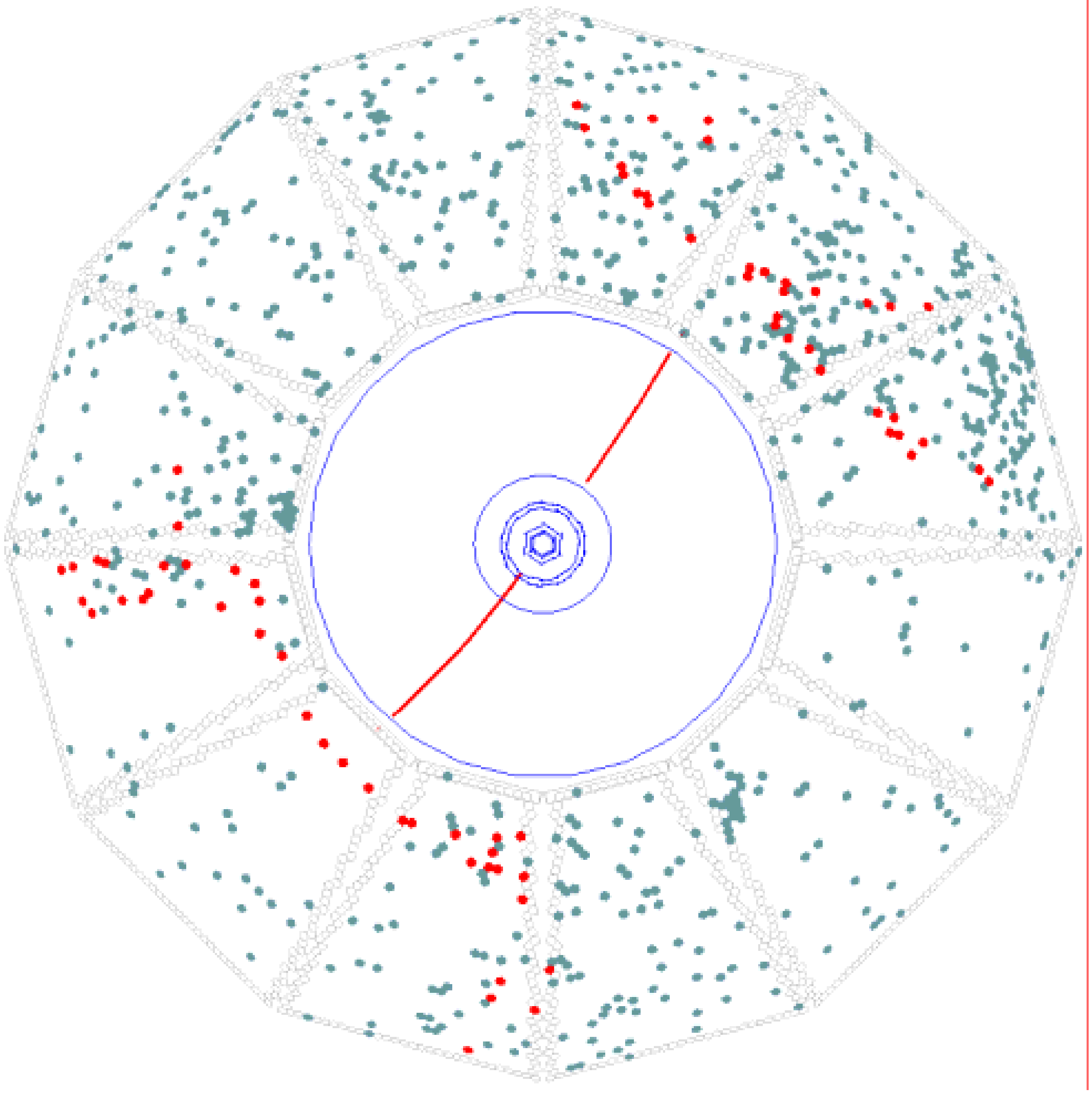


1.7 ns timing

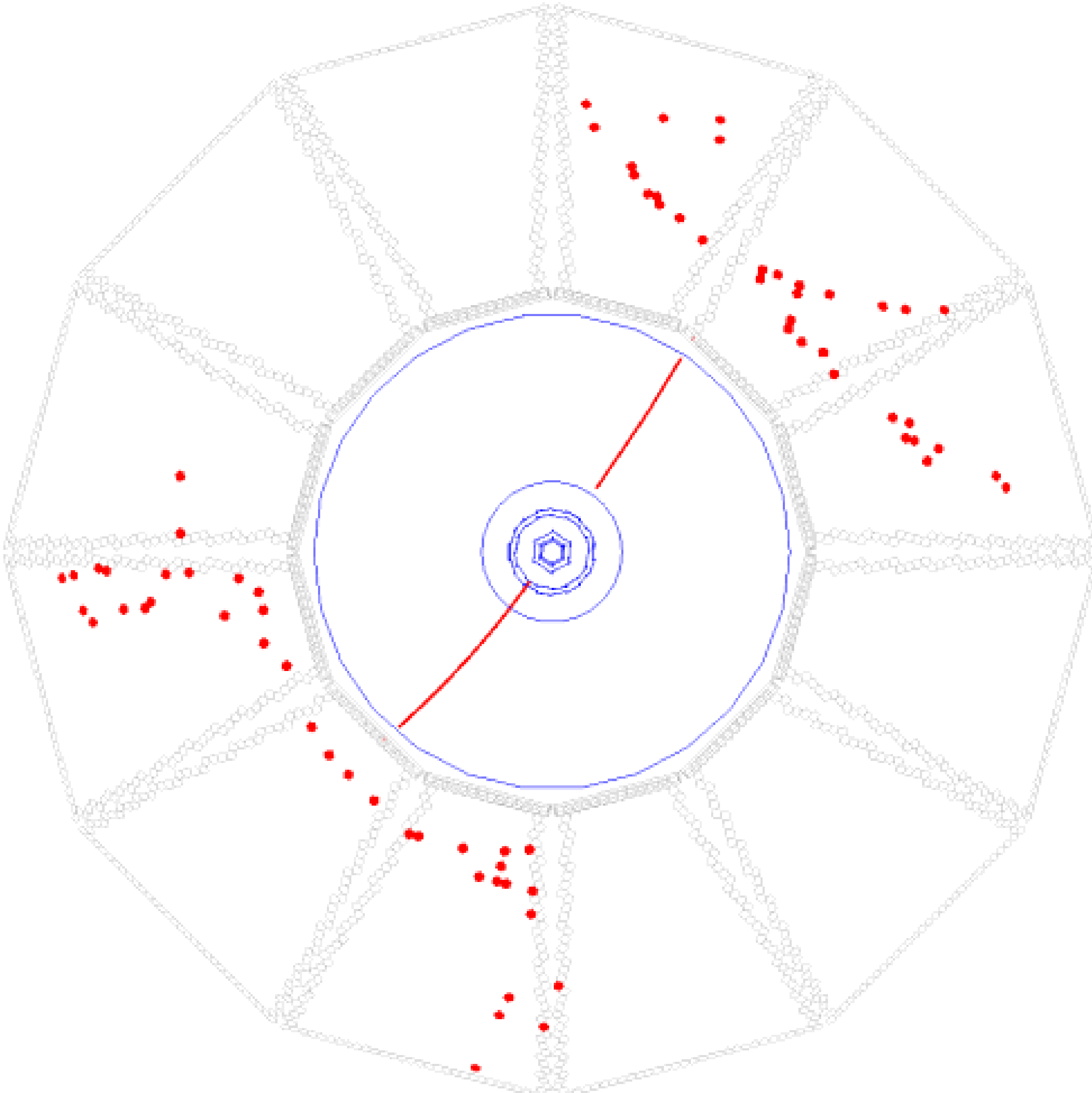


2.5 mrad Θ_c

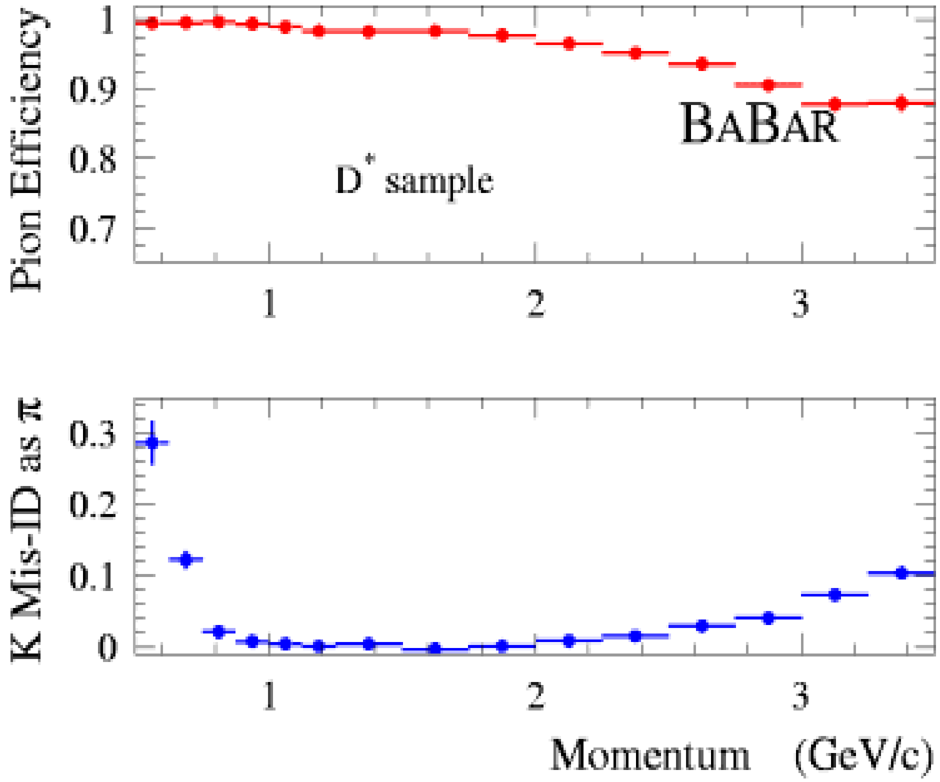
DIRC raw hits(0.6μs window)



DIRC raw hits(0.008μs window)

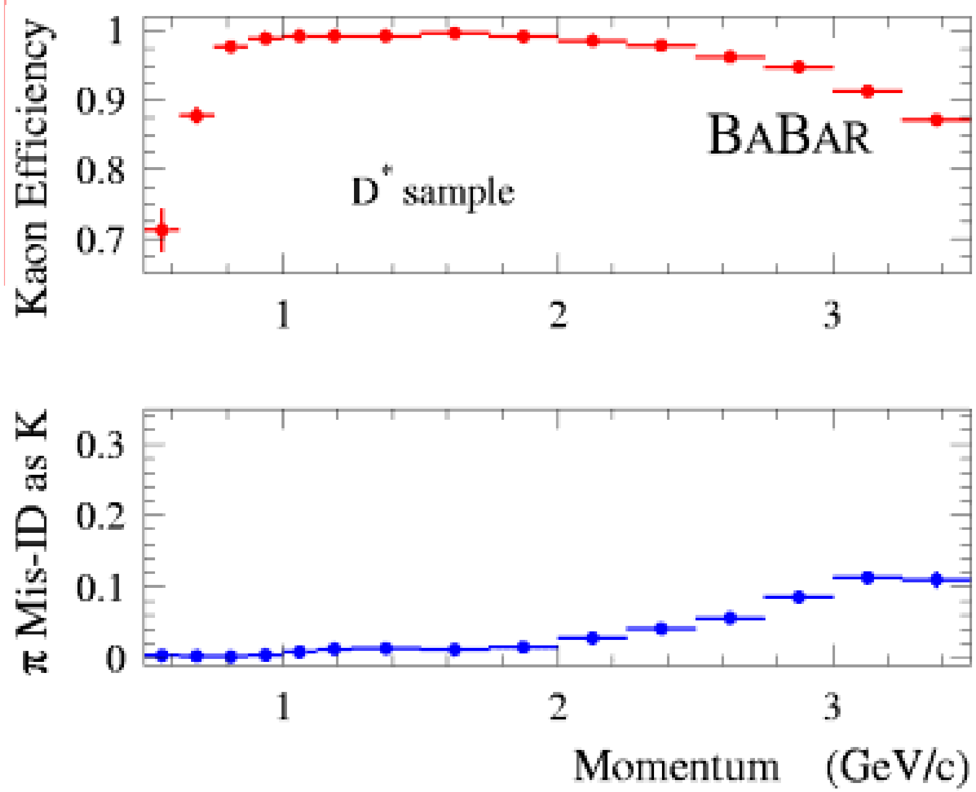


DIRC principle

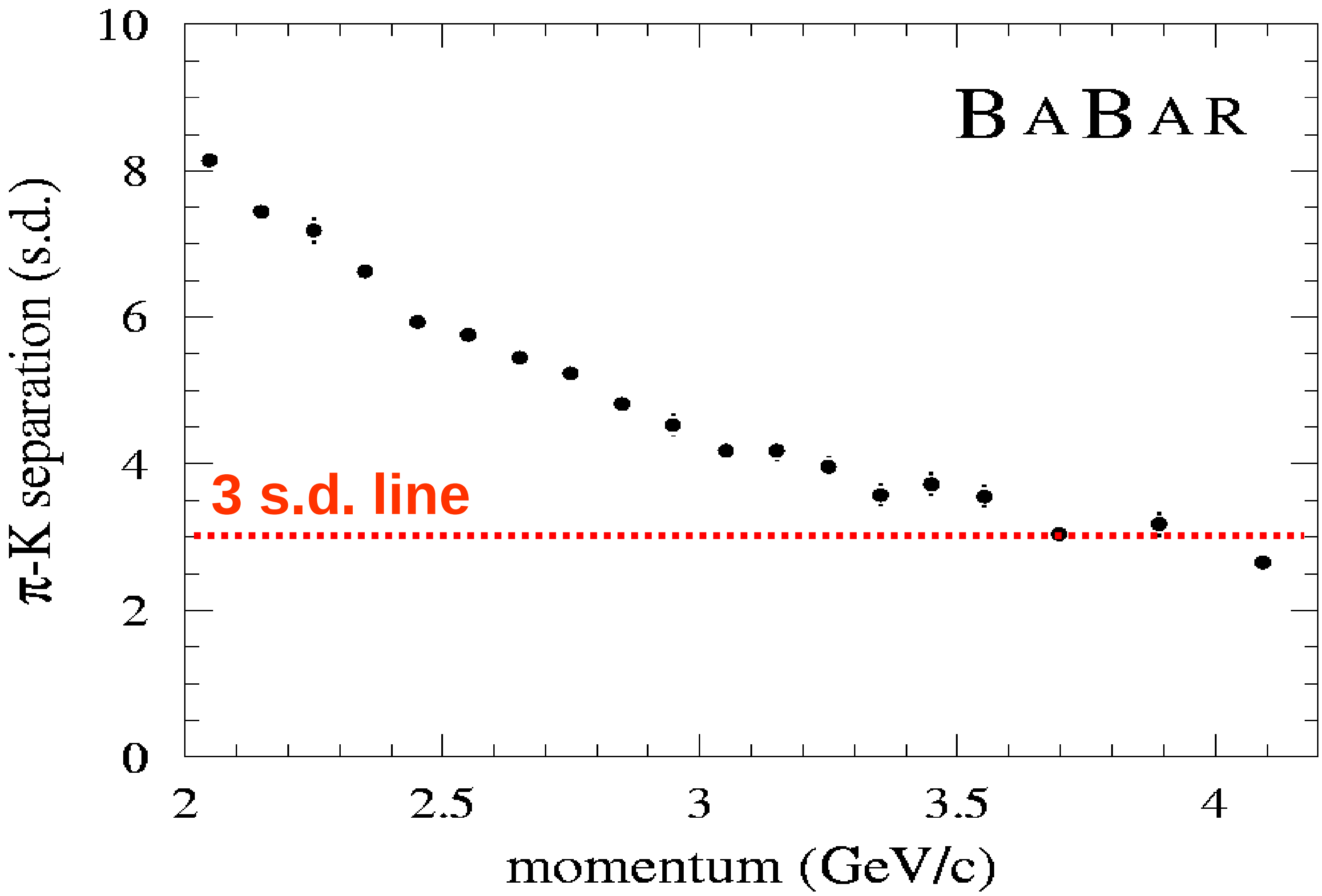


Pion eff and mis-id

Kaon eff and mis-id



DIRC principle

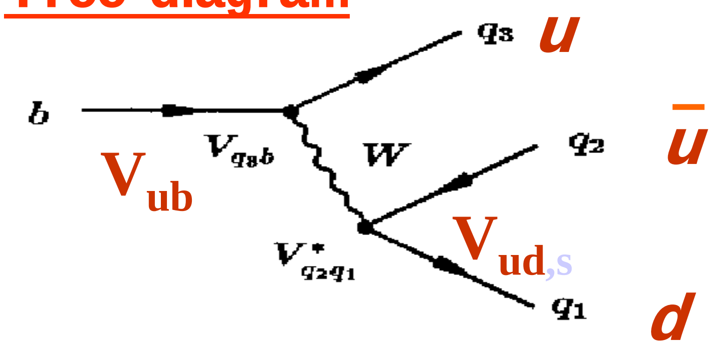


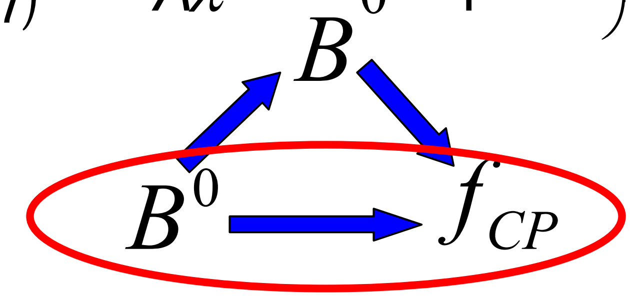
Pi-vs-Kaon separation in units of standard deviations

Charmless B-decays and CKM angle α

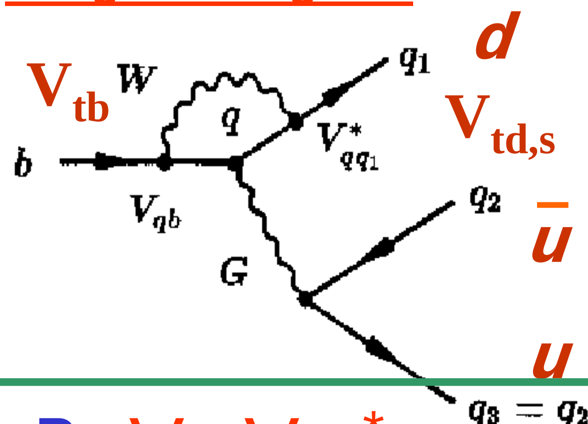
$$V_{CKM} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \qquad V_{CKM} \approx \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

Tree diagram

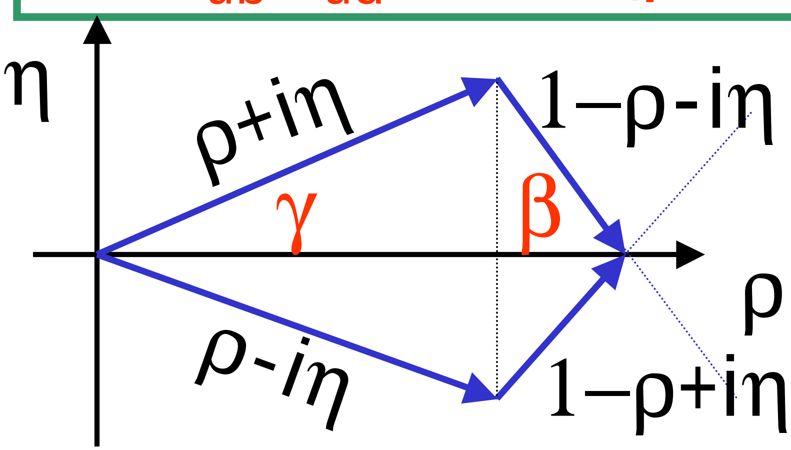




Penguin diagram



$\mathbf{T} \sim V_{ub} V_{ud}^{*} \sim A\lambda^3(\rho - i\eta) x1 \sim e^{-i\gamma}$



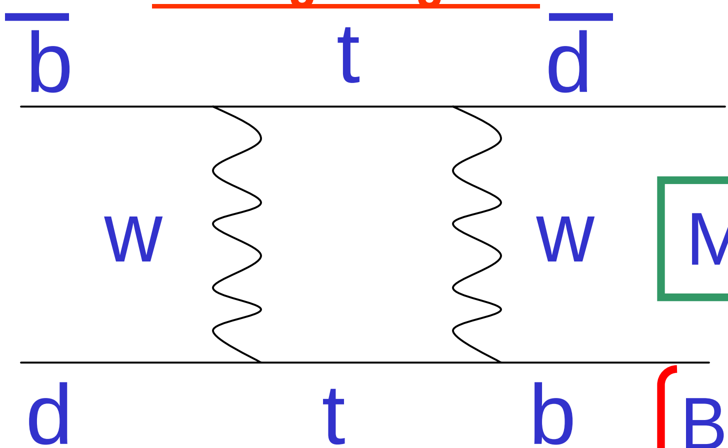
$q=t,\ P \sim V_{tb} V_{td}^{*}$
$\sim 1xA\lambda^3(1-\rho+i\eta) \sim e^{-i\beta}$

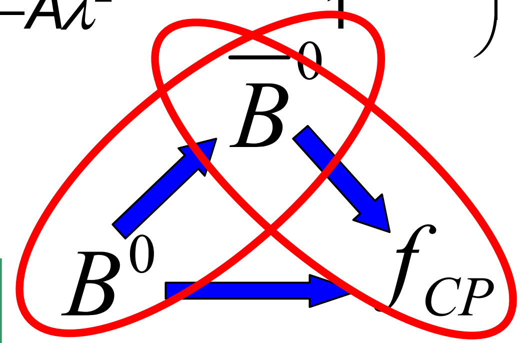
Charmless B-decays and CKM angle α

$$V_{\text{CKM}} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$

$$V_{CKM} \approx \begin{pmatrix} 1-\lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1-\lambda^2/2 & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

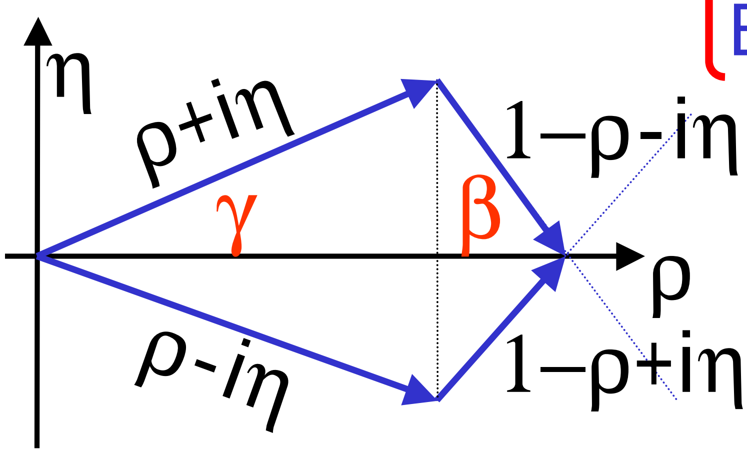
Mixing diagram





$$\boxed{M \sim V_{td}^{2} V_{tb}^{*2} \sim e^{-i2\beta}}$$

$$\begin{cases} B^0 = e^{+i\gamma}T + e^{-i\beta}P = e^{-i\beta}\left(e^{+i(\gamma+\beta)}T + P\right) \\ \overline{B}^0 = \left(e^{-i\gamma}T + e^{+i\beta}P\right)e^{-2i\beta} = e^{-i\beta}\left(e^{-i(\gamma+\beta)}T + P\right) \end{cases}$$



$$\boxed{\begin{aligned} B^0 &= e^{+i\alpha}T + P \\ \overline{B}^0 &= e^{-i\alpha}T + P \end{aligned}}$$

extra phase from mixing

Charmless B-decays and CKM angle α

- every charmless(strangless) B decay is sensitive to α
- the usual suspects are:

$$\begin{cases} B^0 \to \pi^+\pi^- \\ B^0 \to \rho^+\pi^- \\ B^0 \to \rho^+\rho^- \end{cases}$$

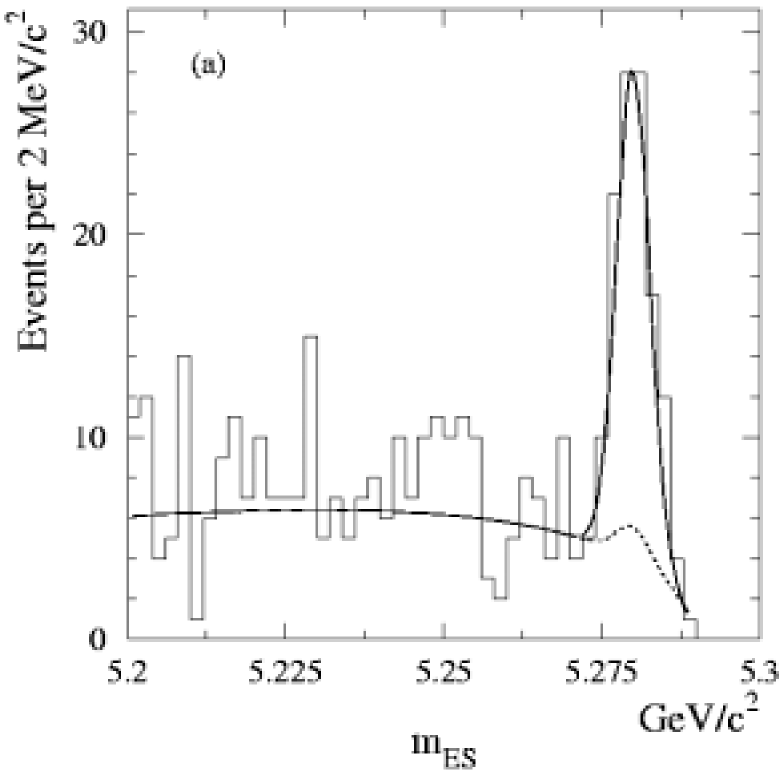
- the quality of the channel is characterized by:

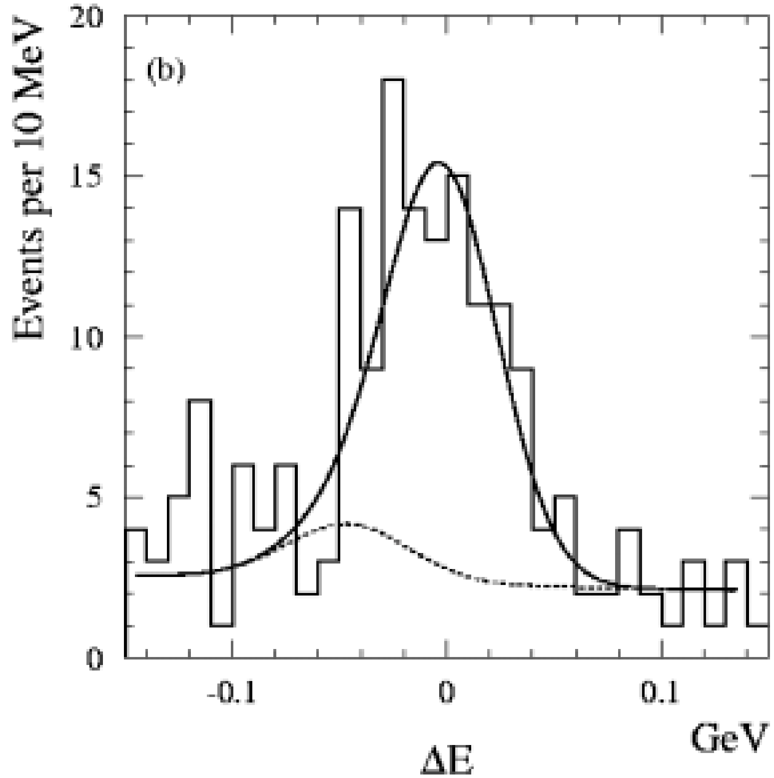
- overall branching ratio
- unknowns-vs-observables, number of ambiguities
- experimental accessibility(number of π^0s in the f.s.)

Selection of B-decays

- kinematically select B candidates with m_{ES}, ΔE

$$m_{ES} = \sqrt{E^{*2}_{\text{beam}} - p^{*2}_{B}} \qquad \Delta E = E^{*}_{B} - E^{*}_{\text{beam}}$$

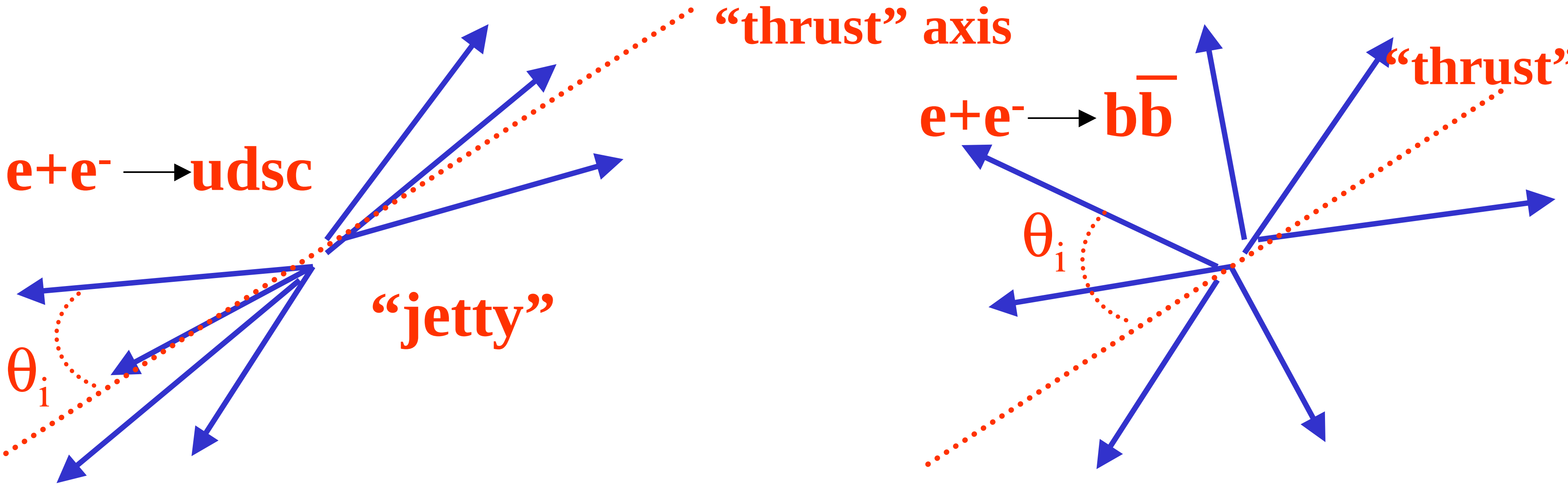




- provides enough separation for channels with Br~10^{-3}

Shape information for rare B-decays

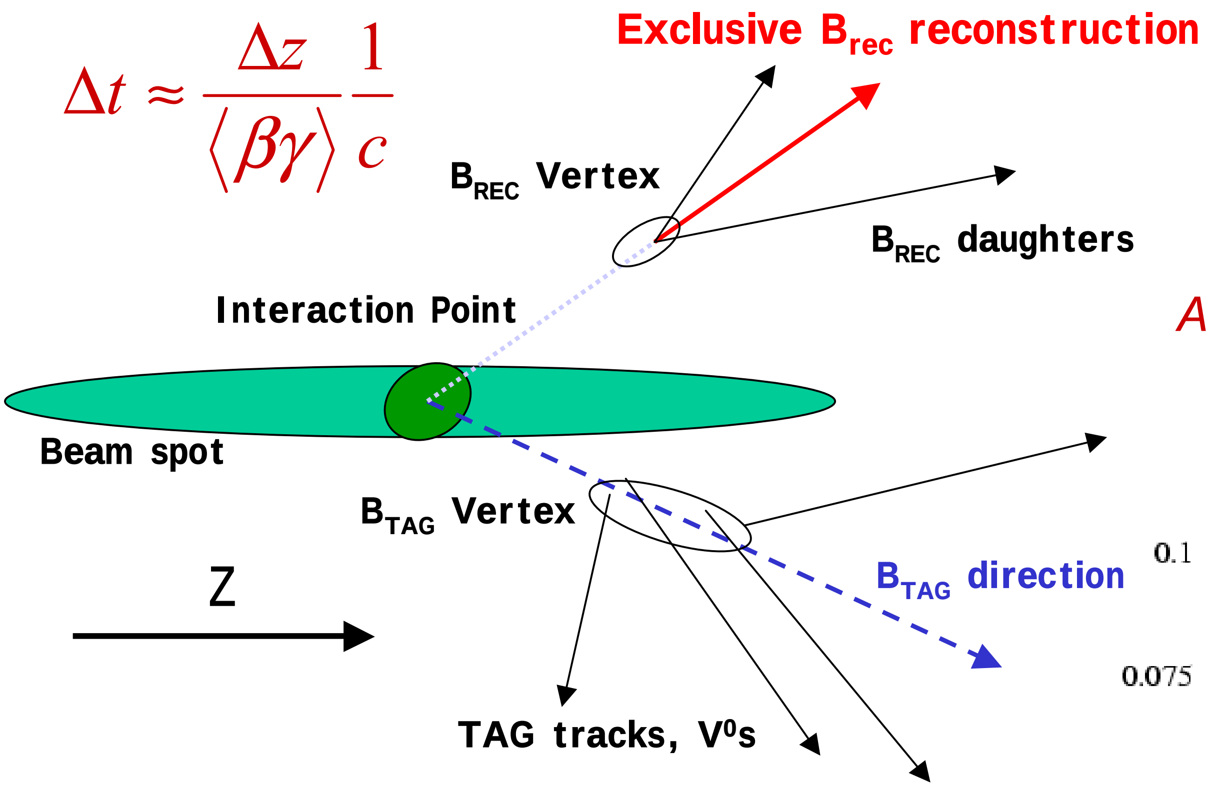
- for "*rare B-decays*"(Br ~ 10^{-4}-10^{-6}), one need to use some extra handles – shape of the event:



$$F = 0.53 - 0.60 \times \sum_i p_i^* + 1.27 \times \sum_i p_i^* \left|\cos(\theta_i^*)\right|^2$$

Vertexing

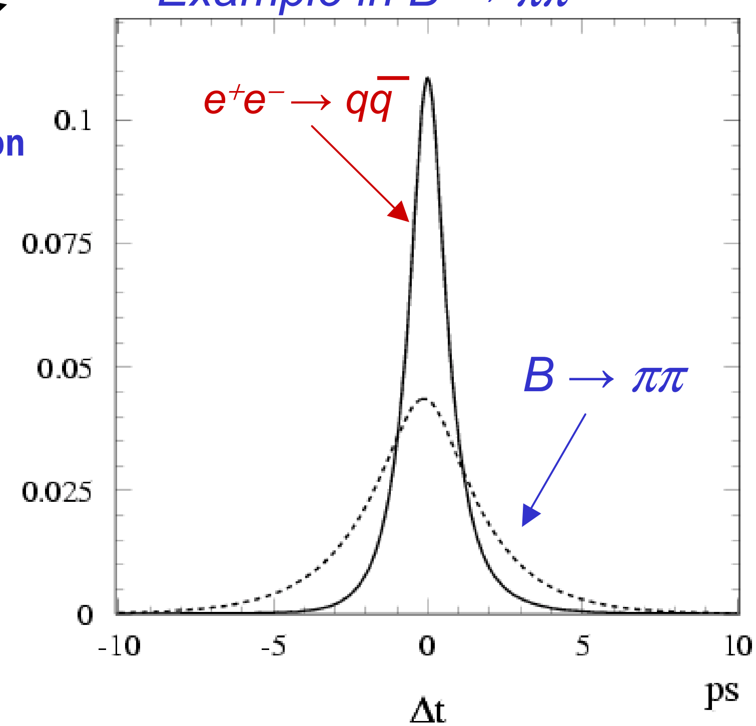
$$\Delta t \approx \frac{\Delta z}{\langle \beta\gamma \rangle} \frac{1}{c}$$



Δz resolution dominated by tag side $\rightarrow$ same resolution function as charmonium ($\sin 2\beta$) sample

Average Δz resolution ~ 180μm

Example in $B \rightarrow \pi\pi$



- Resolution function parameters obtained from data for both signal and background

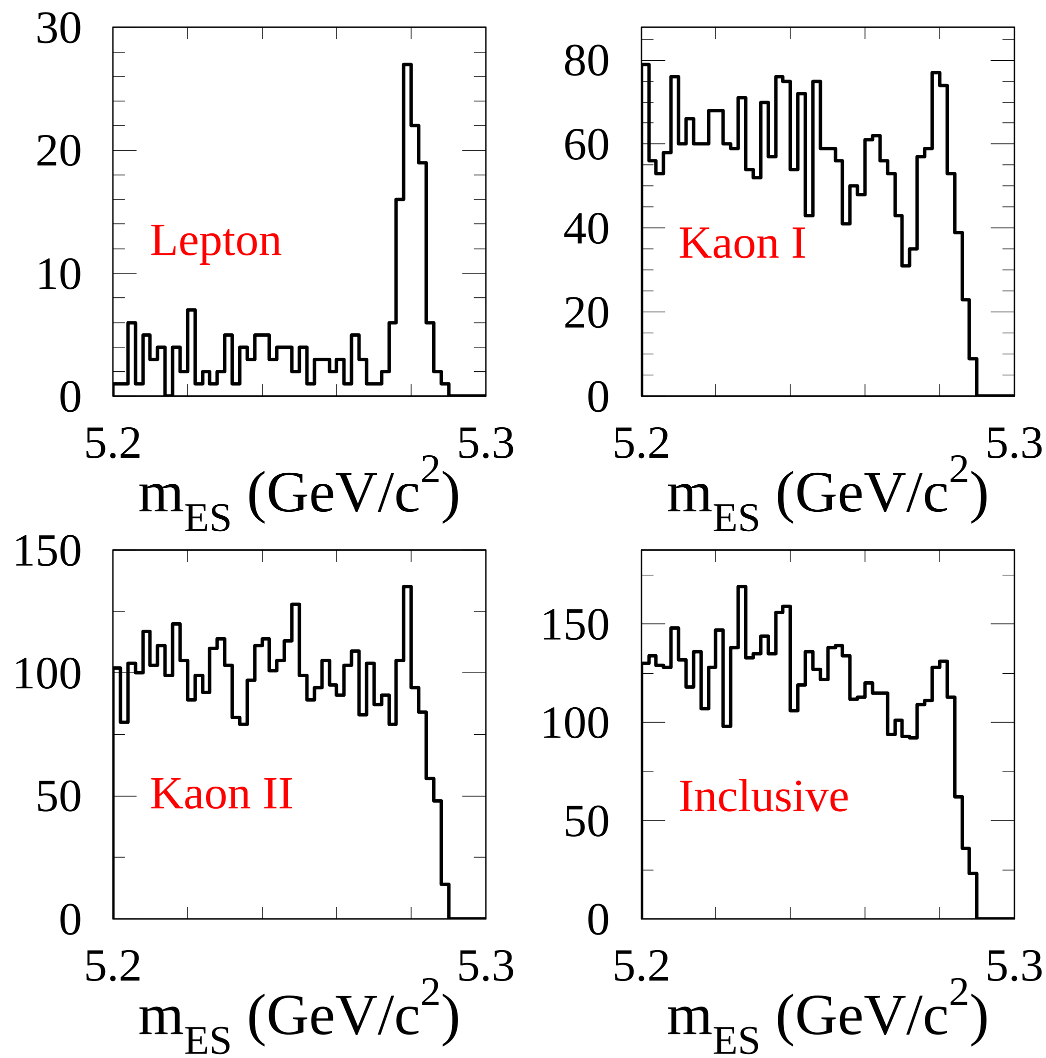
B-flavour tagging

- Tagging efficiency is very different for signal and bkg

Tagging Efficiencies (%)

Category	Signal	Background		
		$\pi\pi$	$K\pi$	KK
Lepton	9.1	0.5	0.4	0.6
Kaon I	16.6	8.9	12.7	7.8
Kaon II	19.8	15.5	19.4	14.4
Inclusive	20.1	21.5	19.2	21.7
Untagged	34.4	53.6	48.3	55.6

81/fb B→ h^+h^- sample split by tagging category



CP Violation in $B^0 \to \pi^+\pi^-$ Decays

$$A_{f_{CP}}(t) \propto S_{f_{CP}} \sin(\Delta m_d t) - C_{f_{CP}} \cos(\Delta m_d t)$$

$$C_{f_{CP}} = \frac{1 - |\lambda_{f_{CP}}|^2}{1 + |\lambda_{f_{CP}}|^2} \qquad S_{f_{CP}} = \frac{2\,\mathrm{Im}\,\lambda_{f_{CP}}}{1 + |\lambda_{f_{CP}}|^2}$$

$$\lambda_{f_{CP}} = \eta_{f_{CP}} \frac{q}{p} \frac{\bar{A}_{\bar{f}_{CP}}}{A_{f_{CP}}}$$

ratio of amplitudes

CP eigenvalue

π^+ $\approx e^{-2i\beta}$

For additional phases:

For a single weak phase (tree):

$$\lambda = \frac{q}{p}\frac{\bar{A}_{\bar{f}}}{A_f} = \eta_f e^{-2i(\beta+\gamma)} = \eta_f e^{2i\alpha}$$

$C_{\pi\pi} = 0$, $S_{\pi\pi} = \sin(2\alpha)$

$$\lambda_{\pi\pi} = e^{2i\alpha} \frac{1+|P/T|e^{i\delta}e^{i\gamma}}{1+|P/T|e^{i\delta}e^{-i\gamma}}$$

$$C_{\pi\pi} \propto \sin(\delta)$$

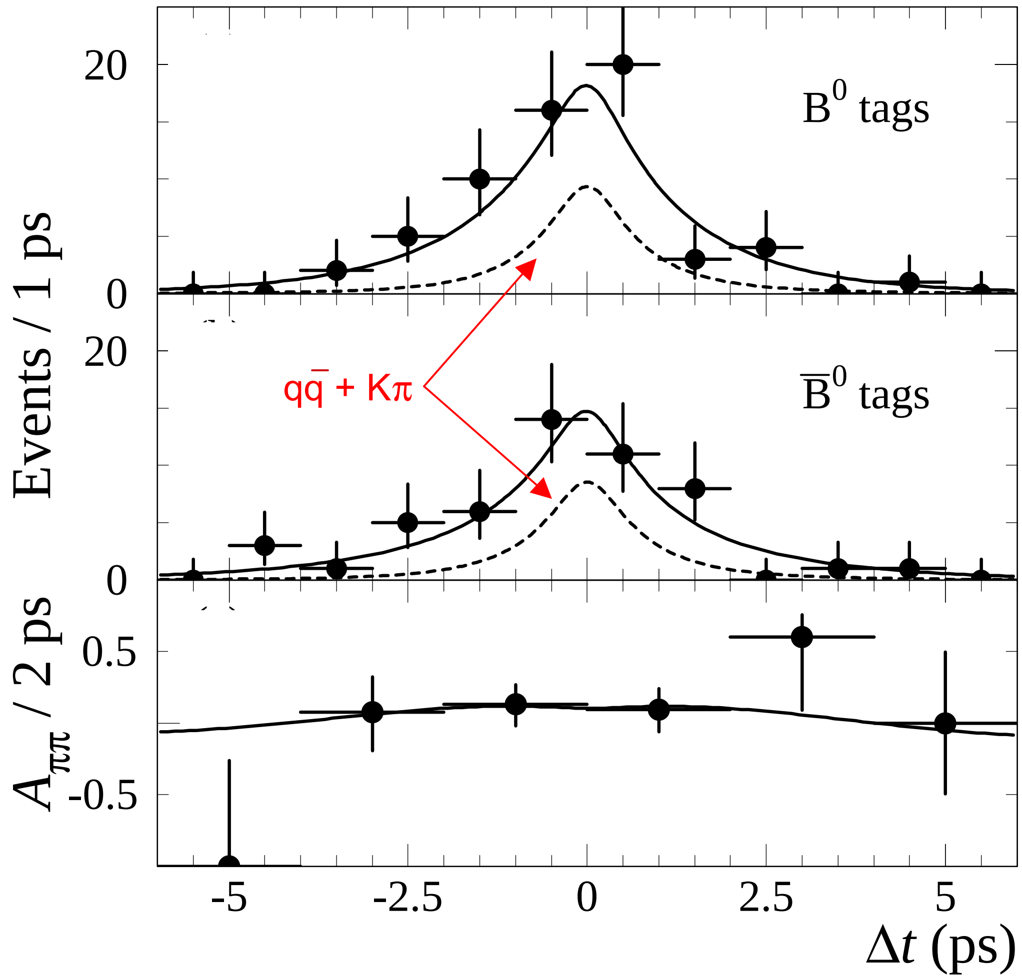
$$S_{\pi\pi} = \sqrt{1 - C_{\pi\pi}^2}\,\sin(2\alpha_{\text{eff}})$$

$C_{\pi\pi} \neq 0$, $S_{\pi\pi} \sim \sin(2\alpha_{\text{eff}})$

Need branching fractions for $\pi^+\pi^-$, $\pi^\pm\pi^0$, and $\pi^0\pi^0$ to get α from α_{eff} $\to$ isospin analysis

CP Asymmetry Results

Fit projection in sample of $\pi\pi$-selected events



Preliminary

$$S_{\pi\pi} = 0.02 \pm 0.34 \pm 0.05$$
$$C_{\pi\pi} = -0.30 \pm 0.25 \pm 0.04$$

Submitted to Phys Rev (hep-ex/0207055)

$$A_{\pi\pi}(\Delta t) \equiv \frac{N\left(B^0_{tag}\right) - N\left(\overline{B}^0_{tag}\right)}{N\left(B^0_{tag}\right) + N\left(\overline{B}^0_{tag}\right)}$$
$$= S_{\pi\pi}\sin(\Delta m_d \Delta t) - C_{\pi\pi}\cos(\Delta m_d \Delta t)$$

Taming the Penguins. Isospin Analysis.

Gronau and London, Phys. Rev. Lett. 65, 3381 (1991)

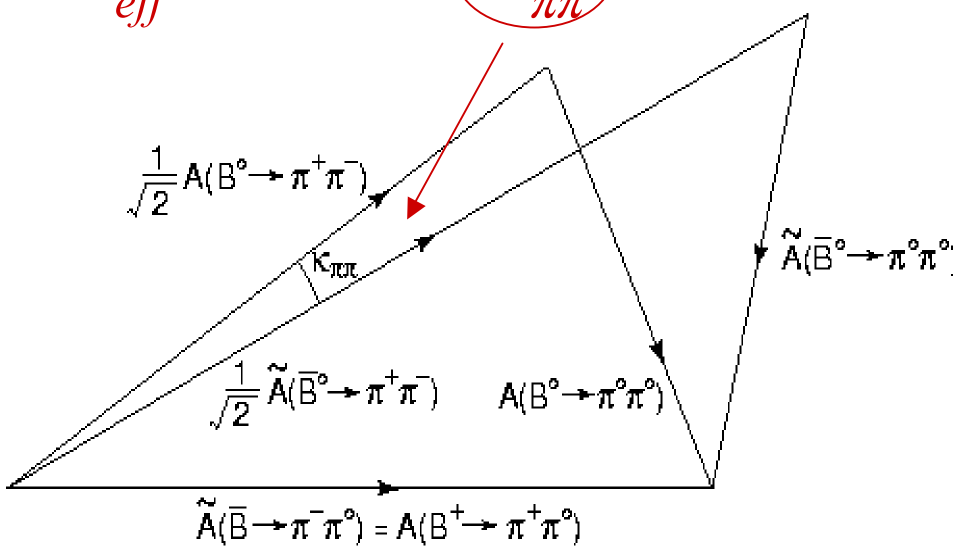
- The decays $B \longrightarrow \pi^+\pi^-$, $\pi^+\pi^0$, $\pi^0\pi^0$ are related by isospin
- Central observation is that $\pi\pi$ states can have I = 2 or 0
  - (gluonic) penguins only contribute to I = 0 (ΔI = 1/2)
  - $\pi^+\pi^0$ is pure I = 2 (ΔI = 1/2) so has only tree amplitude

  $\rightarrow$ ($|A^{+0}| = |A^{-0}|$)

$$2\alpha_{eff} = 2\alpha + \kappa_{\pi\pi}$$

- Triangle relations allow determination of penguin-induced shift in α

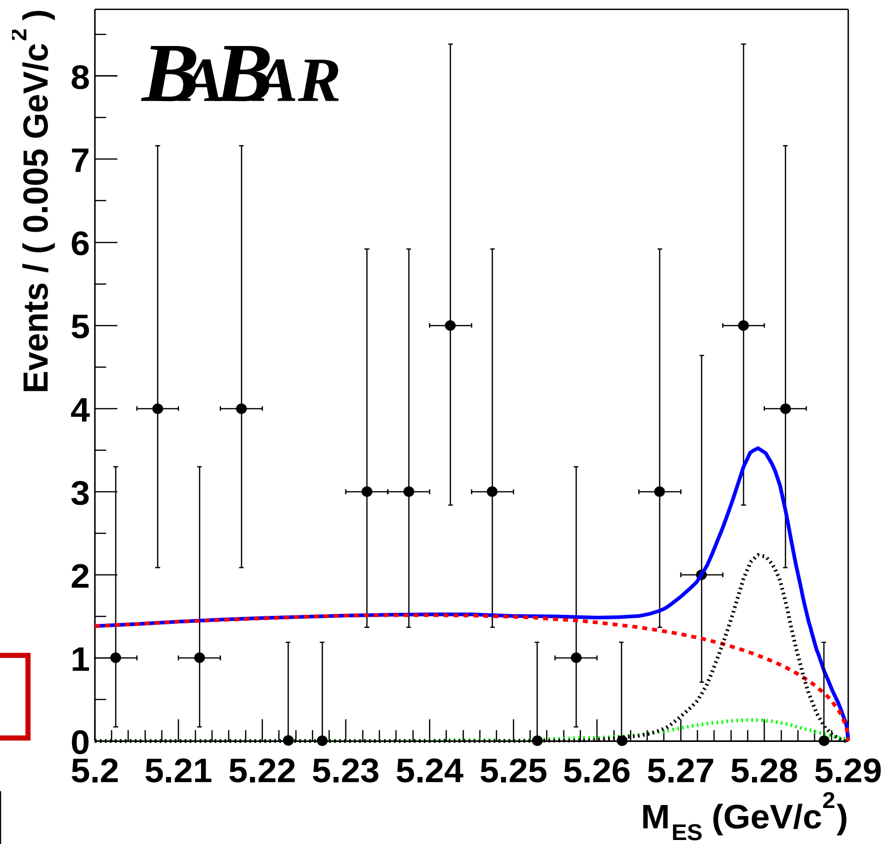
But, need branching fractions for all three decay modes, and for B^0 and $\overline{B^0}$ separately



$B^0 \to \pi^0\pi^0$

- Analysis issues:
  - Small signal!
    $\rho\pi^0$ feeddown
- Background suppression:
  - Event shape and flavor tagging to reduce qq
  - Cut on $M(\pi^+\pi^0)$ and ΔE to reduce $\rho\pi^0$ background, then fix in the fit

Data after cut on probability ratio ($\varepsilon \sim 20\%$)



hep-ex/0207063

Preliminary

$$N_{\pi^0\pi^0} = 23^{+10}_{-9}$$

$$B(B^0 \to \pi^0\pi^0) < 3.6\times10^{-6} \text{ @ } 90\% \text{ C.L.}$$

Significance including systematic errors = 2.5σ

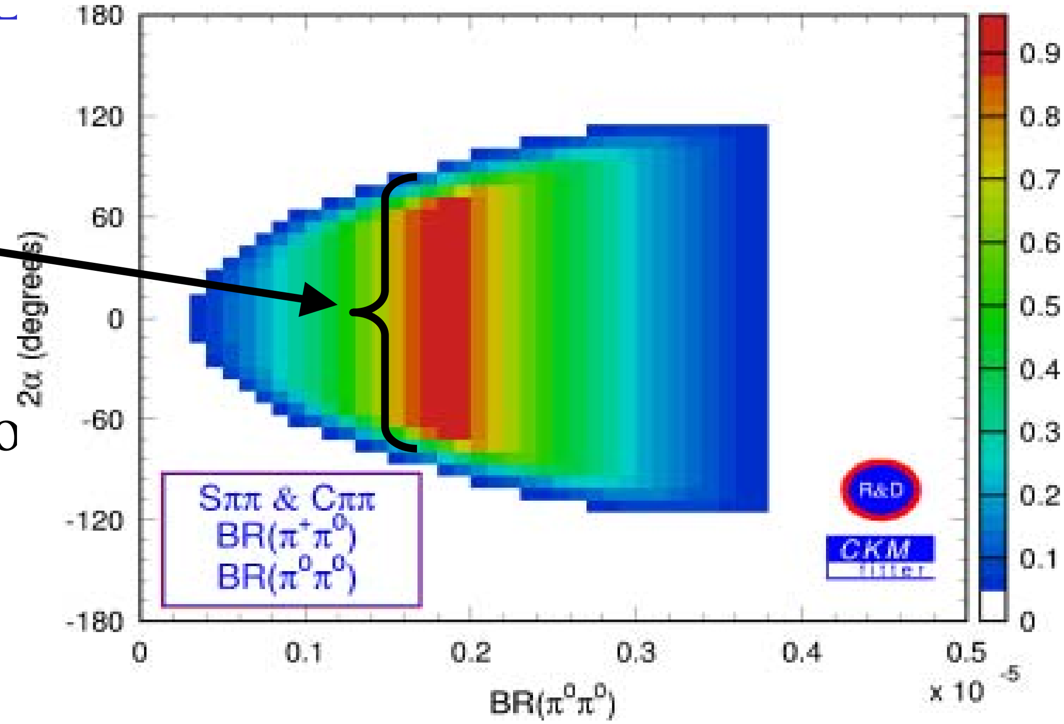
Setting a Bound on Penguin Pollution

- Can still get information on α with only an upper bound on $\pi^0\pi^0$:
  - For example: Grossman-Quinn bound (assume only isospin)

$$\sin^2(\alpha_{\text{eff}} - \alpha) < \frac{\frac{1}{2}\left[BR(B^0 \to \pi^0\pi^0) + BR(\overline{B}^0 \to \pi^0\pi^0)\right]}{BR(B^\pm \to \pi^\pm\pi^0)}$$

$$< 0.61 \text{ @ } 90\% \text{ C.L}$$

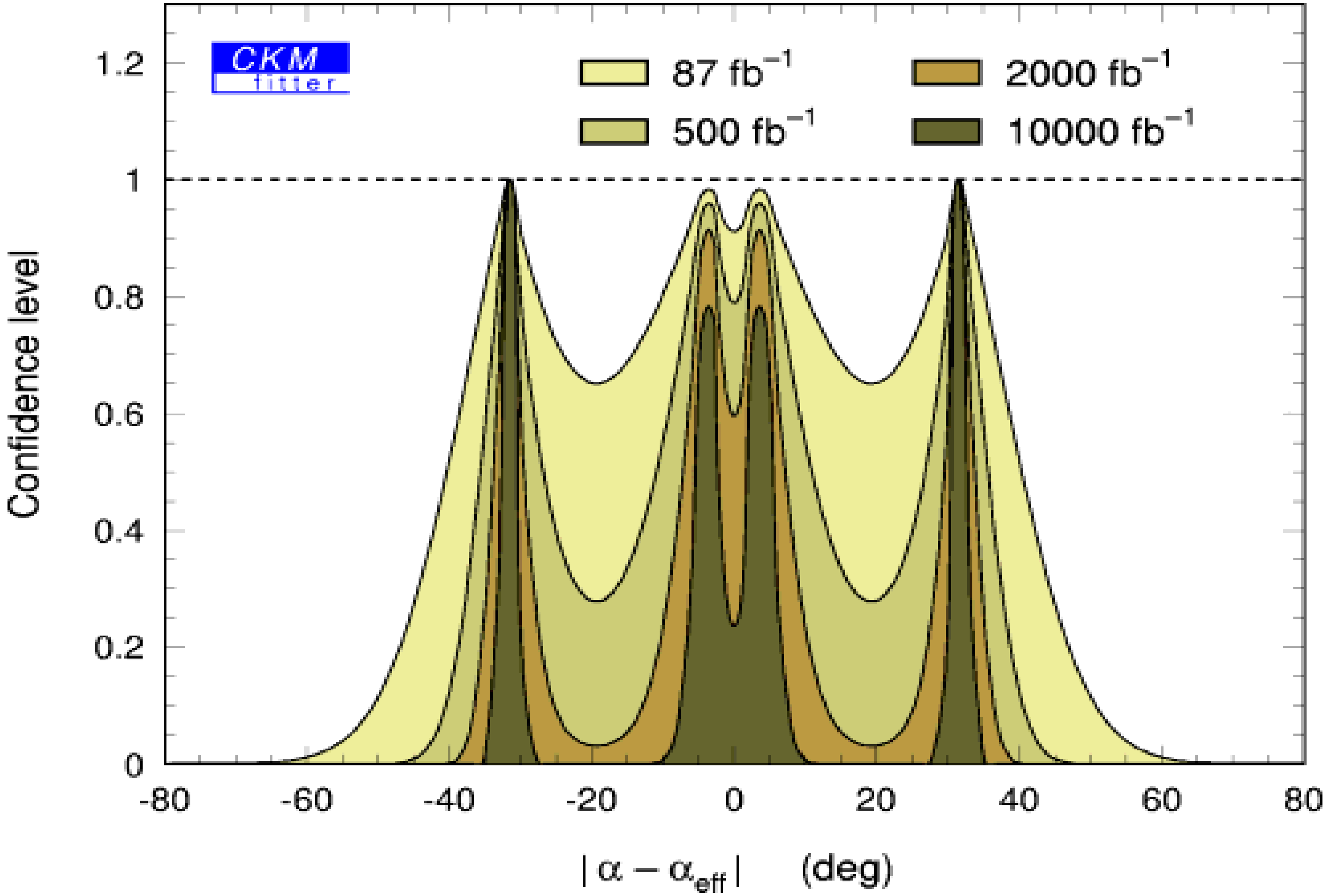
$$\left|\alpha_{\text{eff}} - \alpha\right| < 51^\circ \text{ @} 90\% \text{ C.L.}$$



- Many other bounds on the market (Charles,Gronau/Londo /Sinha/Sinha, etc…)

How about More Statistics?

Isospin analysis for present central values, but more statistics



If central value of BR($\pi^0\pi^0$) stays large, isospin analysis cannot be performed by first generation B factories

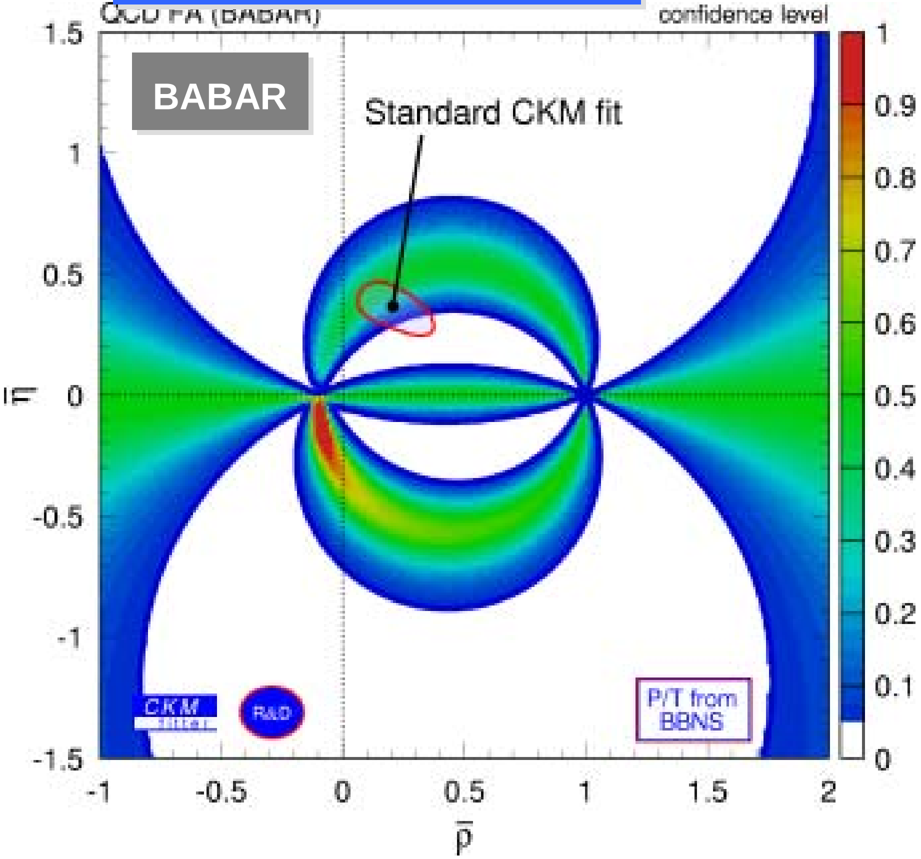
BaBar-vs-Belle

BABAR	
$S_{\pi\pi}$	$+0.02 \pm 0.34$
$C_{\pi\pi}$	-0.30 ± 0.25

P/T| and arg(P/T) predicted by QCD FA (BBNS'01)

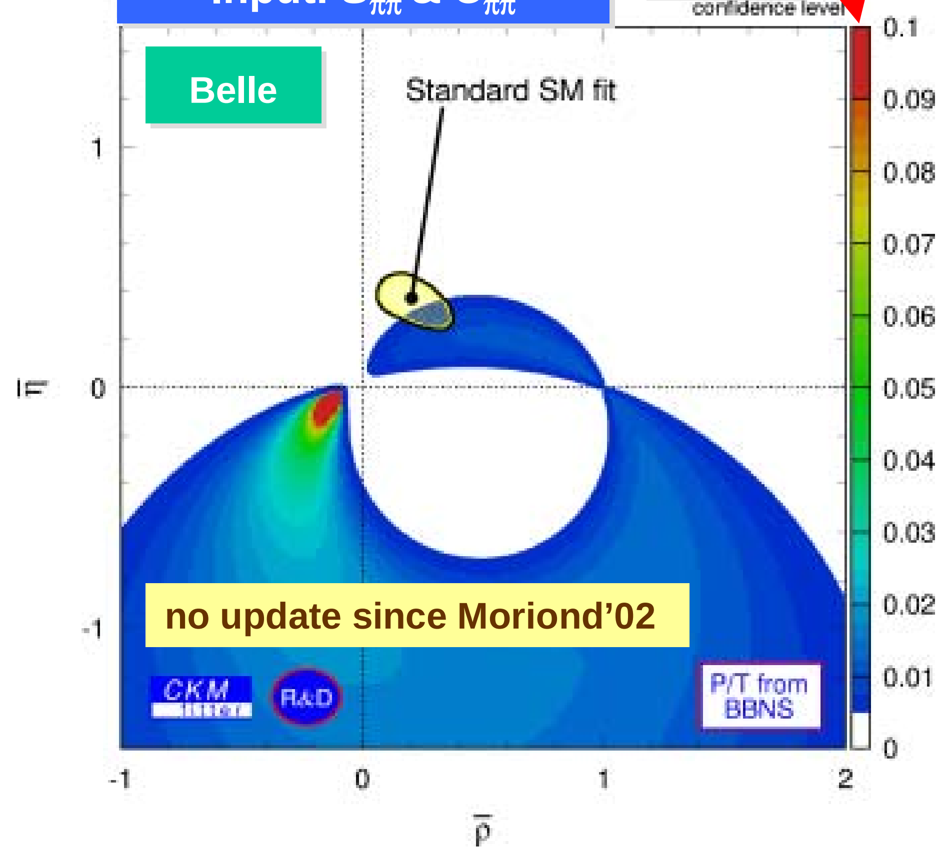
Belle	
$S_{\pi\pi}$	-1.21+0.45(-0.30)
$C_{\pi\pi}$	-0.94 + 0.32(-0.27)

Input: $S_{\pi\pi}$ & $C_{\pi\pi}$



Input: $S_{\pi\pi}$ & $C_{\pi\pi}$

Zoom



CP-Violating Asymmetries in $B^0 \rightarrow \rho^+\pi^-, \rho^+K^-$

- **Opportunity and challenges**
  - In principle, can measure a directly, even with penguins
  - Much more difficult than $\pi^+\pi^-$
    - Three-body topology with neutral pion (combinatorics, lower efficiency)
    - Significant fraction of misreconstructed signal events and backgrounds from other B decays
    - Need much larger sample than currently available to extract a cleanly
- We perform a "quasi-two-body" analysis:
  - Select the ρ–dominated region of the $\pi^+\pi^-\pi^0/K^+\pi^-\pi^0$ Dalitz plane
  - Use multivariate techniques to suppress qq backgrounds
  - Simultaneous fit for $\rho^+\pi^-$ and ρ^+K^-

Observables

Not a CP eigenstate, (at least) four amplitudes contribute:

Time-integrated asymmetry:

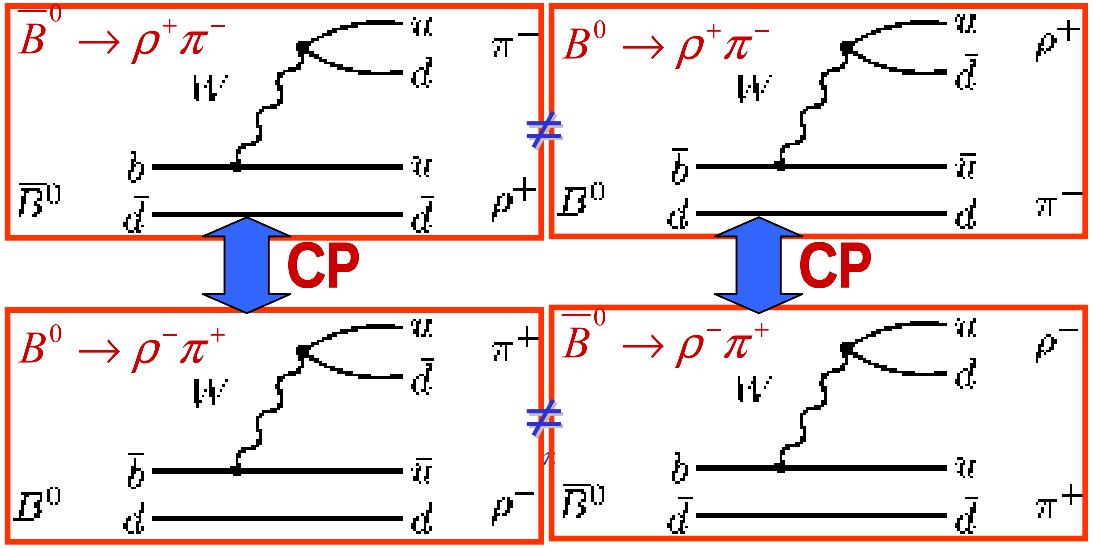
$$A_{CP}^{\rho h} = \frac{N(\rho^+ h^-) - N(\rho^- h^+)}{N(\rho^+ h^-) + N(\rho^- h^+)}$$

Time evolution includes:

$$(S_{\rho h} + Q\Delta S_{\rho h})\sin(\Delta m_d \Delta t)$$

$$(C_{\rho h} + Q\Delta C_{\rho h})\cos(\Delta m_d \Delta t)$$

Q is the ρ charge



direct CP violation → A_{CP} and C ≠ 0

indirect CP violation → S ≠ 0

ρK is self-tagging:

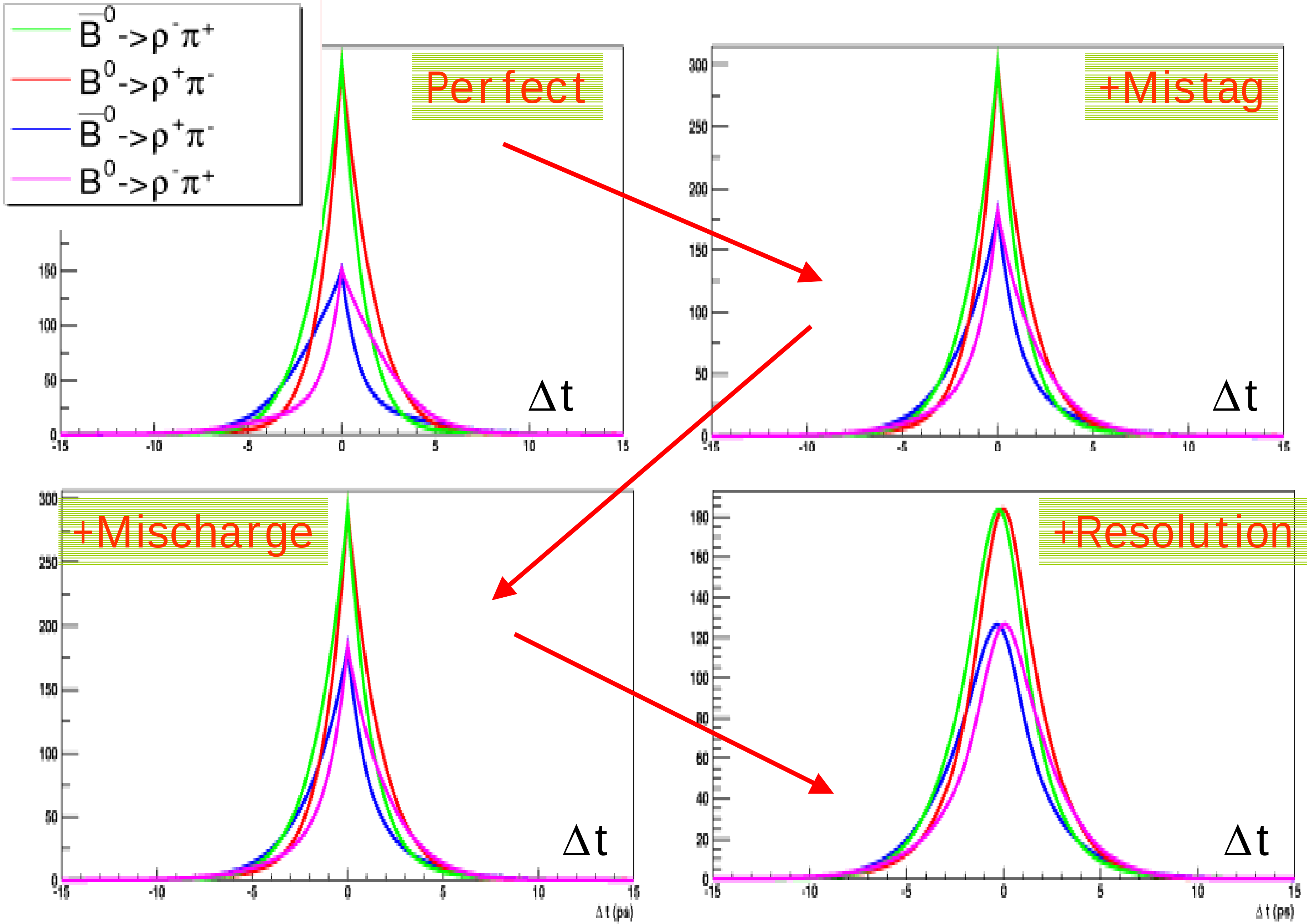
$$C_{\rho K} = 0, \Delta C_{\rho K} = -1, S_{\rho K} = 0, \Delta S_{\rho K} = 0$$

Fit for:

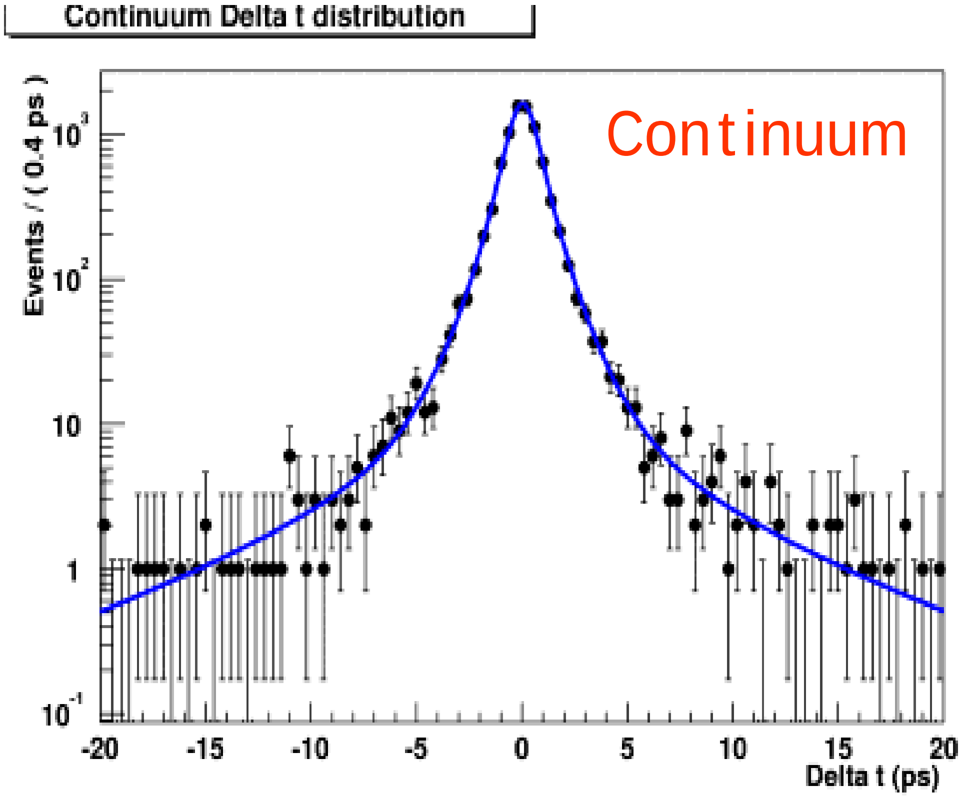
$$\boxed{A_{CP}^{\rho\pi}, A_{CP}^{\rho K}, C_{\rho\pi}, \Delta C_{\rho\pi}, S_{\rho\pi}, \Delta S_{\rho\pi}}$$

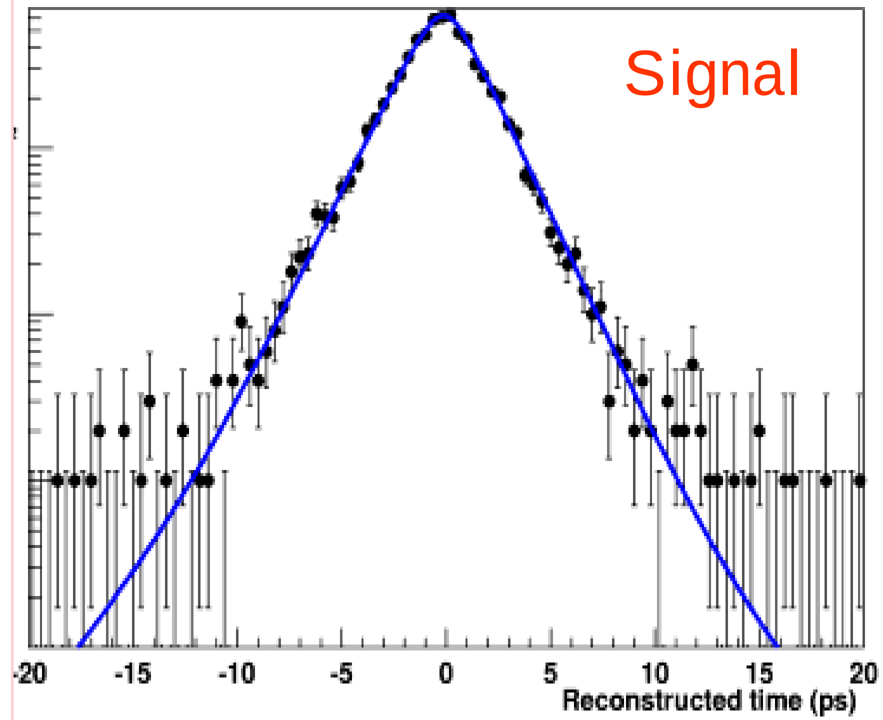
ΔC and ΔS are insensitive to CP violation

Degradation of time resolution



PDFs for time distributions





– 3 Gaussian with common mean

– widths are scaled with Δt per-event error(fit is biased otherwise)

– tagging and charge of the final state are correlated - evaluated from off-peak

– convoluted by BaBar official resolution function extracted from independent, high-statistics sample of B events(the same for all CP analyses at BaBar)

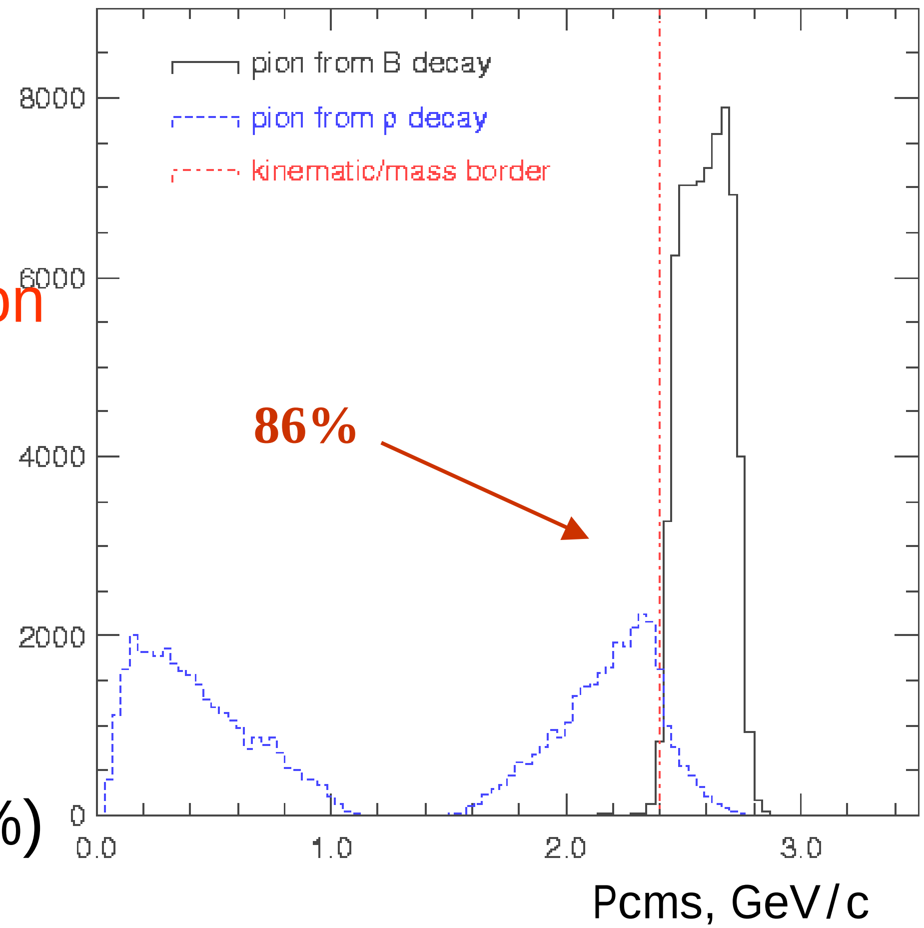
– scaled with Δt per-event error

Charge determination

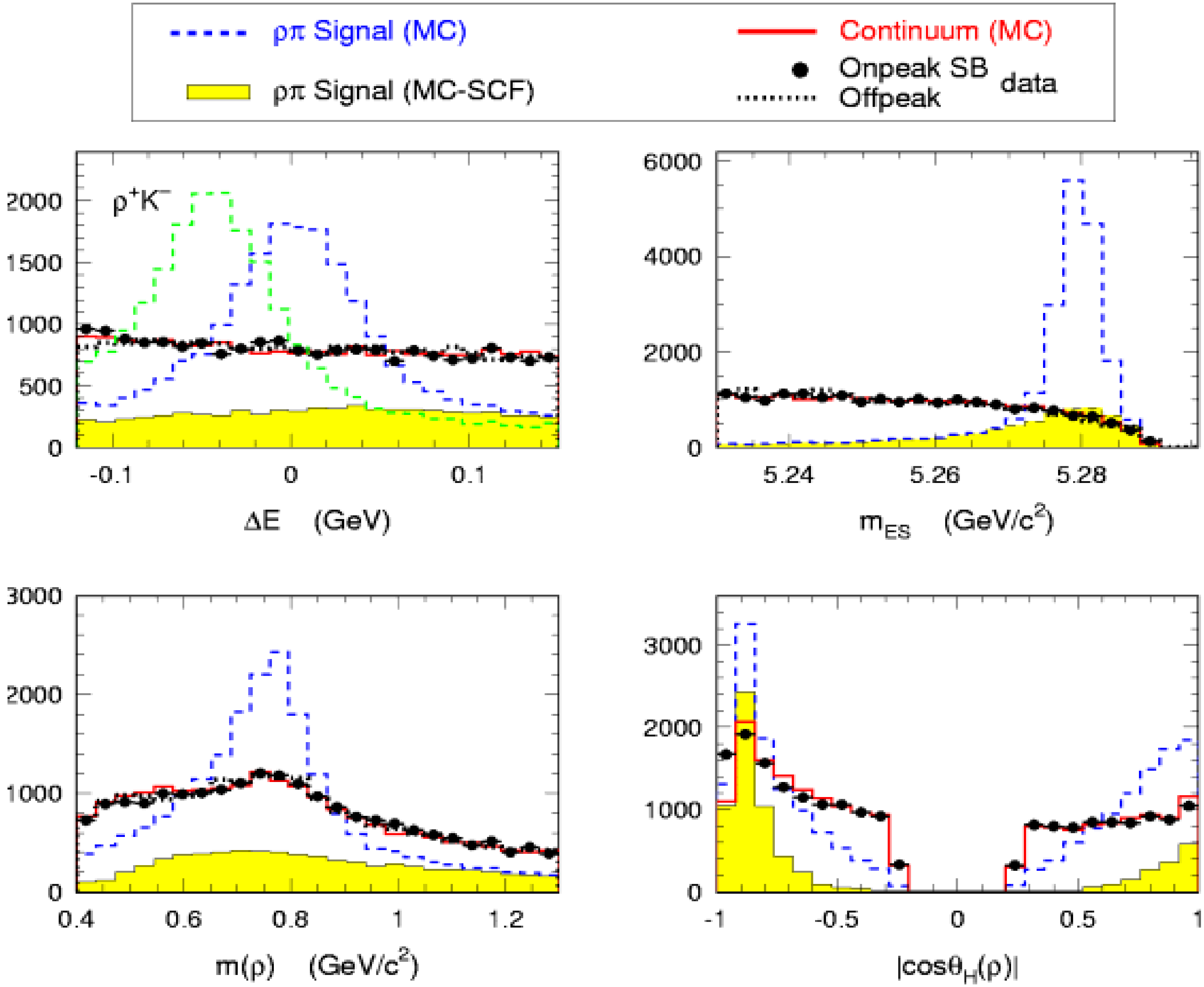
- <u>candidate selection:</u>
  based on best π^0 mass
- self-cross feed(wrong π^0 fraction) is ~30%(26%)

– <u>ρ charge reconstruction:</u>
  depends on P^* of slowest pion
– ρ charge is the charge of the slowest pion if $P^* < 2.4\,GeV/c^2$ (independent of π^0 reconstruction!)
- best ρ mass if $P^* > 2.4\,GeV/c^2$

- ρ mis-charge fractions ~5%(1%)



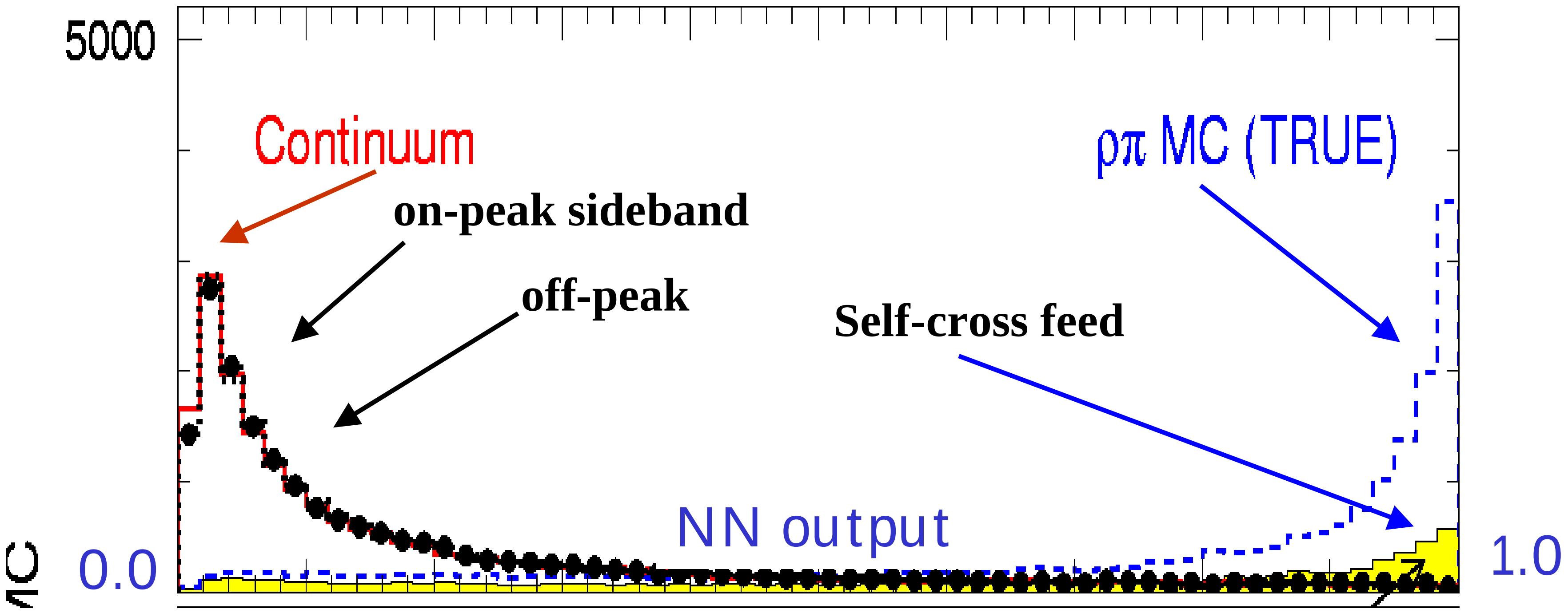
Signal-vs-continuum PDFs



Choice of the continum discriminator

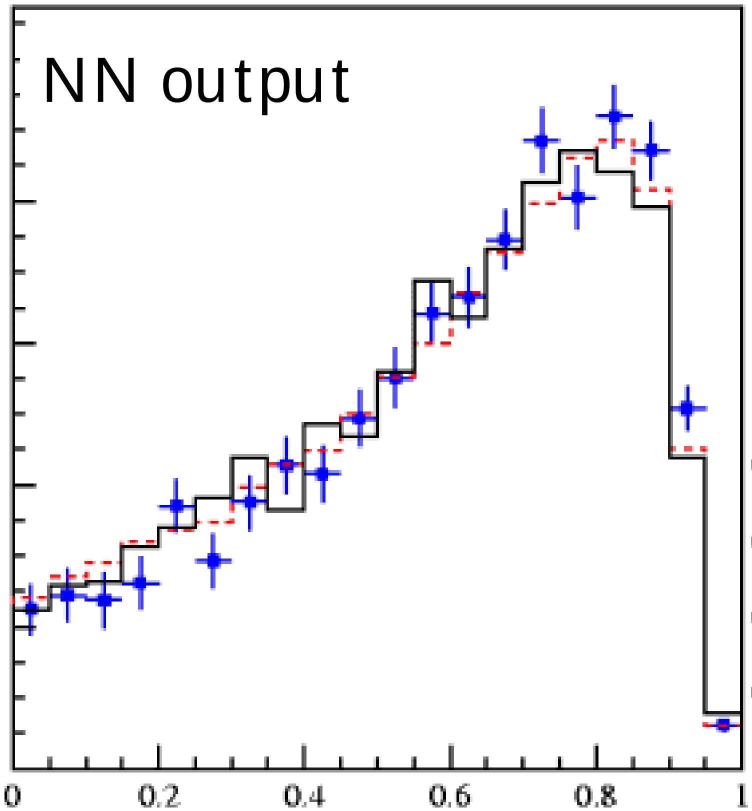
- we considered a large number of event shape variables to be used for discrimination against continuum background, and decided to use the simplest one:

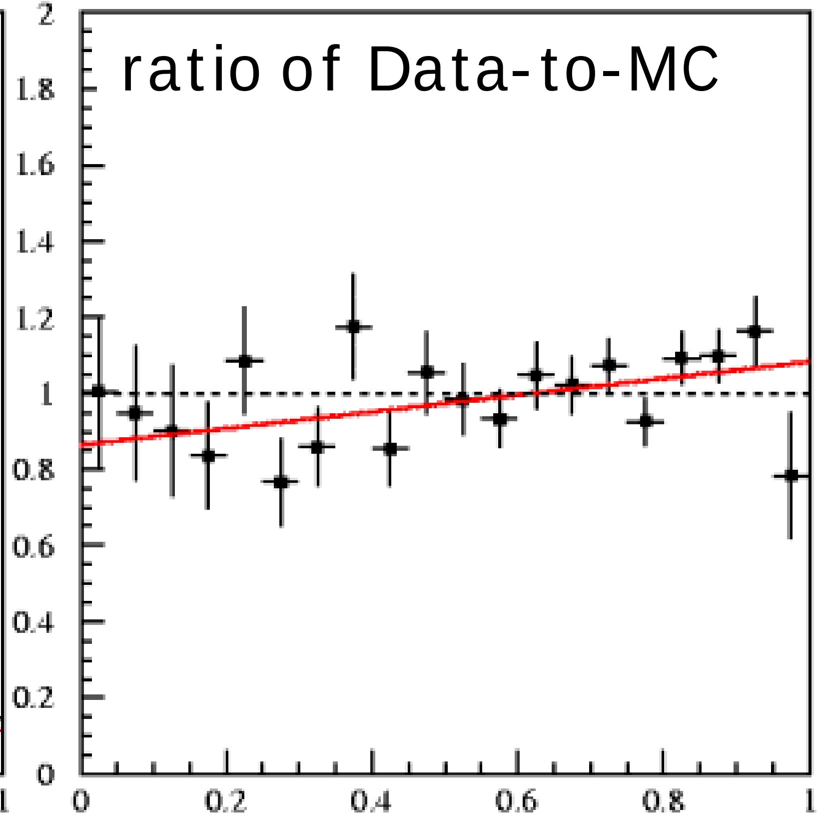
NN with 4 variables(Base): **m(ρ), cosθ_H(ρ), L0, L2**



Validation of MVA

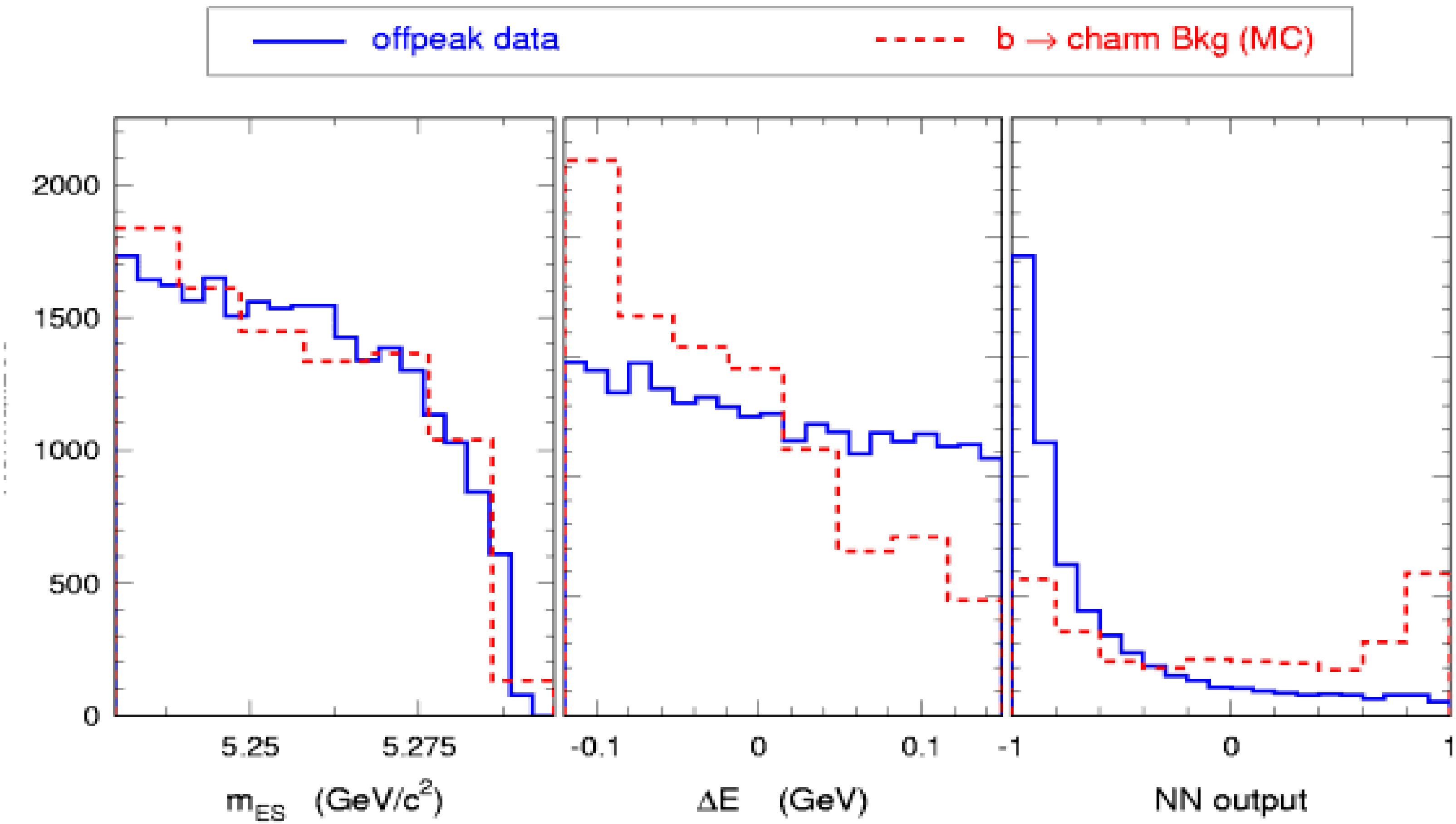
- we used fully reconstructed $B^0 \to D^{\pm}\rho^{\mp}$ events and compared NN output for Data and MC($D^{\pm}\rho^{\mp}, \rho^{\pm}\pi^{\mp}$)





B $\longrightarrow$ charm background

Using 34.0x10^{6} B^0B^0 and 26.0x10^{6} B^+B^- of generic MC events, we found that after all cuts there will be 1.6%(compared to udsc) contamination.



2 PDFs for charged and neutral components are is added

Charmless background

started with ~100 2,3,4-body charmless modes from Monte Carlo

all selection cuts are applied,
N(expected) > 1 event is required

end up with 29 2,3,4-body charmless modes

the biggest contributions are taken exclusively, others are grouped together according to their CP properties

12 PDFs are added to the Likelihood function

Charmless background

- **Charged B decays(e.g. $B^+ \to \rho^0 \pi^+$):**

$$P(\Delta t, \mathrm{tag} = \pm, \mathrm{charge} = \pm) = w_{\mathrm{tag,charge}} \mathrm{e}^{-|\Delta t/\tau|}$$

$$w_{\mathrm{tag,charge}} = \{B^0 \rho^+; B^0 \rho^-; \overline{B}^0 \rho^+; \overline{B}^0 \rho^-; \mathrm{NoTag}\}$$

- **Neutral self-tagging(e.g. $B^0 \to K^{*+}\pi^-$):**

$$f_{B^0 tag}^{K^{*+}\pi^-} = \frac{e^{-|\Delta t|/\tau}}{4\tau}\left[1 + \frac{\Delta D}{2} + \langle D \rangle \cos(\Delta m_d \Delta t)\right] \mathrm{w}_{\mathrm{charge}}$$

$$f_{B^0 tag}^{K^{*-}\pi^+} = \frac{e^{-|\Delta t|/\tau}}{4\tau}\left[1 + \frac{\Delta D}{2} - \langle D \rangle \cos(\Delta m_d \Delta t)\right] \mathrm{w}_{\mathrm{charge}}$$

- **Neutral non-self-tagging(e.g. $B^0 \to \rho^+ \rho^-$):**

- mis-charge and mis-tag Rates are absorbed into $S_{\mathrm{eff}}^{\pm}, C_{\mathrm{eff}}^{\pm}$

- for CP-eigen states, $S_{eff}^{+} = S^{-}_{eff}, C_{eff}^{+} = C_{eff}^{-}$

$$f_{B^0 tag}^{\pm} = \frac{e^{-|\Delta t|/\tau}}{4\tau}\left[1 + \left(S_{eff}^{\pm} \sin(\Delta m_d \Delta t) - C_{eff}^{\pm} \cos(\Delta m_d \Delta t)\right)\right]$$

$$f_{\overline{B}^0 tag}^{\mp} = \frac{e^{-|\Delta t|/\tau}}{4\tau}\left[1 + \left(S_{eff}^{\mp} \sin(\Delta m_d \Delta t) - C_{eff}^{\mp} \cos(\Delta m_d \Delta t)\right)\right]$$

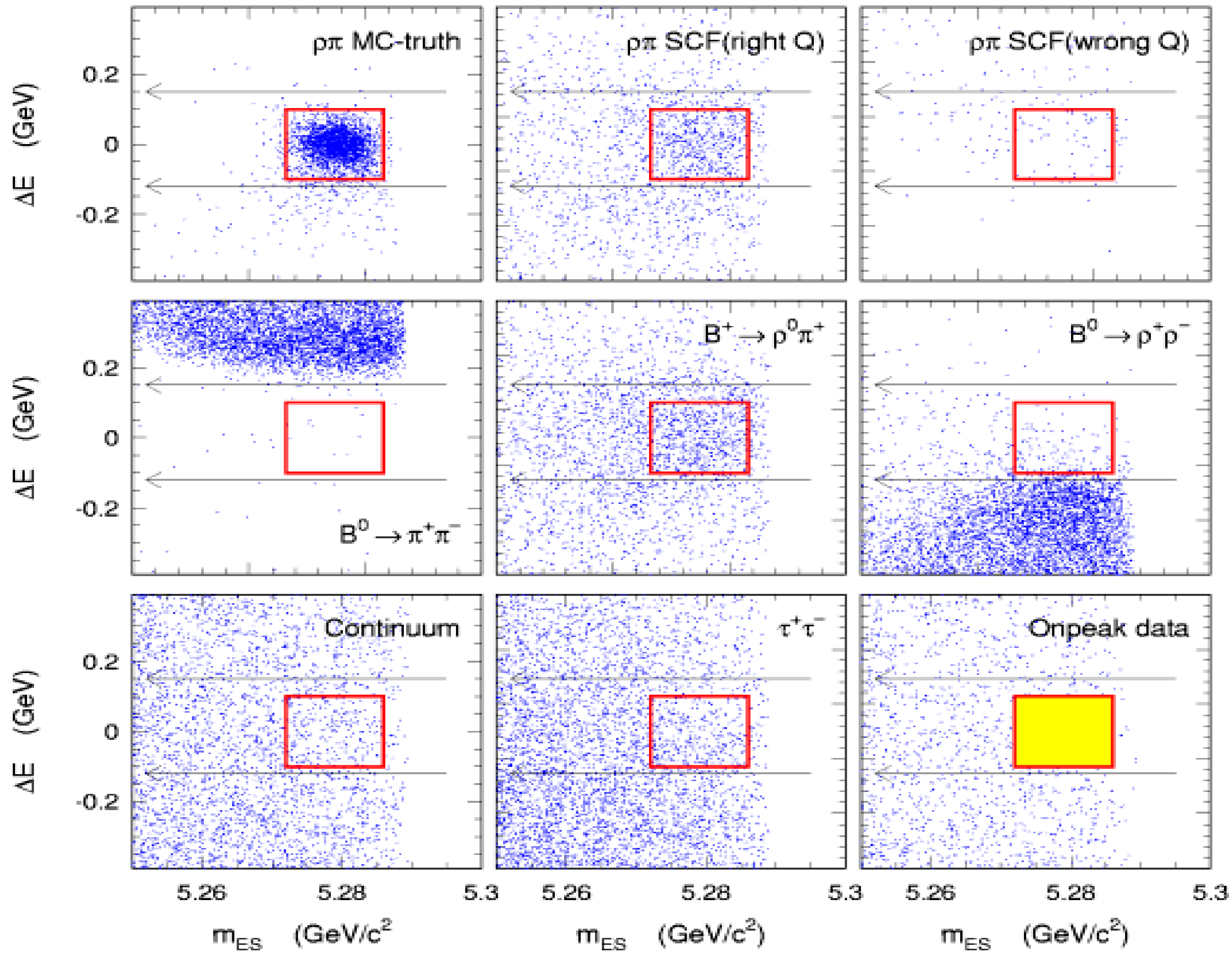
Charmless background(charged)

Cl	Id	Mode	N^{π}_{exp}	N^{K}_{exp}	A_{π}	A_K
0	3	$B^+ \to \rho^+ K^{*0}(\to K^+\pi^-)$ [long]	0.0 ± 0.0	2.8 ± 2.9	-1	-1
0	13	$B^+ \to \rho^+ \rho^0_{\text{[long]}}$	21.6 ± 16.8	0.0 ± 0.0	0.09 ± 0.03	-
0	43	$B^+ \to \eta'(\to \rho^0\gamma)\pi^+$	0.0 ± 1.0	0.0 ± 0.0	-0.86 ± 0.03	-
0	42	$B^+ \to \eta'(\to \rho^0\gamma)K^+$	0.1 ± 0.1	7.5 ± 0.6	1	-1
1	51	$B^+ \to \pi^0\rho^+$	17.1 ± 11.5	0.0 ± 0.0	-1	-
1	58	$B^+ \to \pi^+\rho^0$	29.3 ± 8.4	0.0 ± 0.0	-0.47 ± 0.02	-
1	55	$B^+ \to K^0_S(\to \pi^+\pi^-)\pi^+$	8.1 ± 0.9	0.0 ± 0.0	-0.76 ± 0.04	-
1	53	$B^+ \to K^+\rho^0$	0.9 ± 0.7	9.9 ± 7.6	1	-1
1	-	$B^+ \to K^+ f_X(1300)$	1.8 ± 1.4	16.2 ± 11.3	1	-1
1	57	$B^+ \to K^+ f_0(980)(\to \pi^+\pi^-)$	1.6 ± 0.6	14.6 ± 5.0	1	-1
1	95	$B^+ \to \pi^0 K^{*+}(\to K^+\pi^0)$	0.0 ± 0.0	6.2 ± 3.5	-	-1
2	71	$B^+ \to K^+\pi^0$	0.0 ± 0.0	9.6 ± 0.9	-	-1
2	72	$B^+ \to \pi^+\pi^0$	3.5 ± 0.7	0.0 ± 0.0	-1	-
10	-	$B^+ \to (K_X^{(**)}\pi)^+ \to K^+\pi^-\pi^+$	6.1 ± 3.3	4.3 ± 2.3		
10	-	$B^+ \to (K_X^{(**)}\pi)^+ \to \text{other}$	6.1 ± 6.1	0.0 ± 0.0		-
12	-	$B^+ \to (K_X^{(**)}\rho)^+ \to K^+\pi^-\pi^+ X$	0.8 ± 0.8	1.7 ± 1.7		
7	-	$B^+ \to \text{charm}$	164 ± 36	41 ± 10	-0.21 ± 0.06	-0.75 ± 0.08

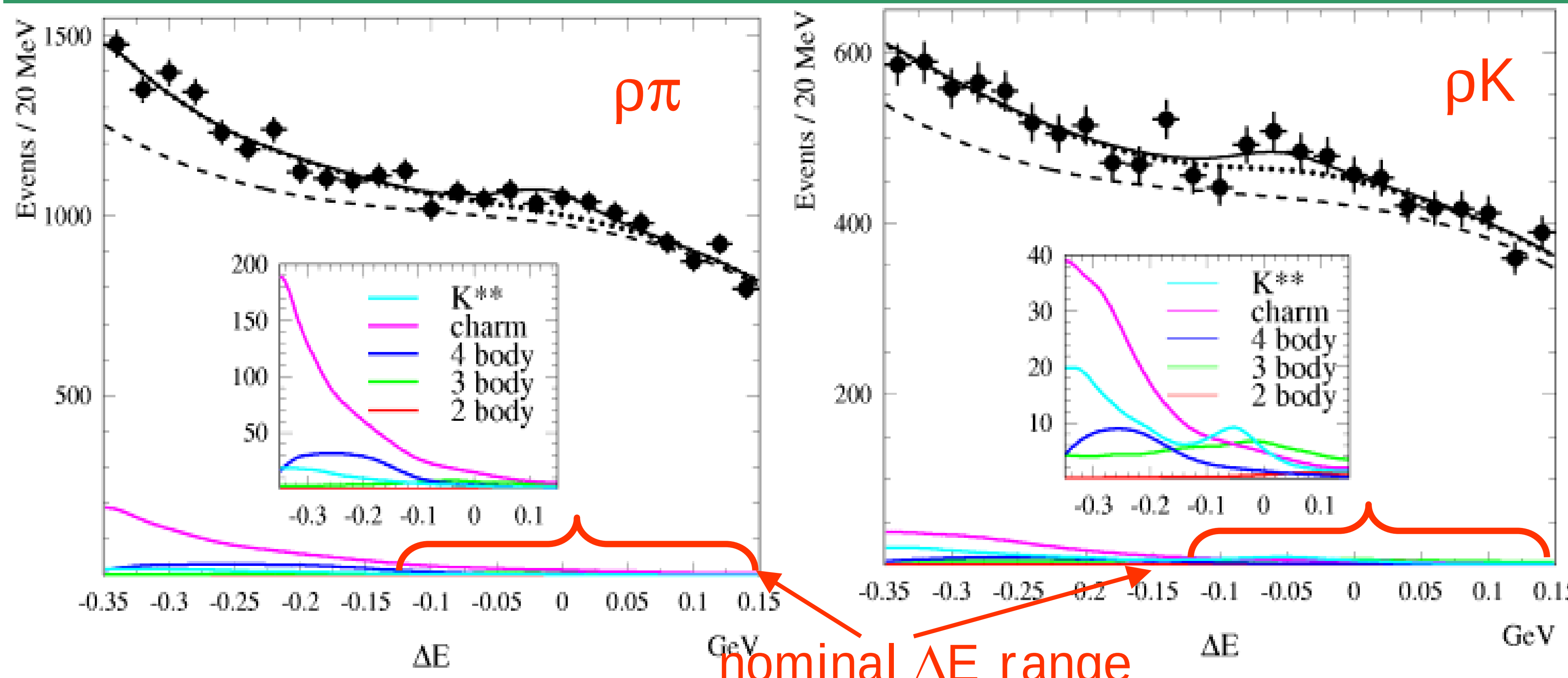
Charmless background(neutral)

Cl	Id	Mode	N^{π}_{exp}	N^{K}_{exp}	ΔC_π	ΔC_K
3	91	$B^0 \to \rho^0 K^{*0}(\to K^+\pi^-)_{[long]}$	0.2 ± 0.2	1.0 ± 1.0	?	?
3	9	$B^0 \to \rho^- K^{*+}(\to K^+\pi^0)_{[long]}$	0.4 ± 0.4	2.8 ± 2.8	1	-1
3	44	$B^0 \to \pi^- K^{*+}(\to K^0_S\pi^+)$	2.5 ± 1.5	0.0 ± 0.0	1	-
4	15	$B^0 \to \rho^+\rho^-_{[long]}$	49.0 ± 36.8	0.0 ± 0.0	-	-
4	17	$B^0 \to \rho^0\rho^0_{[long]}$	2.4 ± 2.4	0.0 ± 0.0	-	-
5	56	$B^0 \to (a_1\pi)^0$	8.3 ± 5.6	0.0 ± 0.0	-	-
5	56	$B^+ \to (a_1\pi)^+$	10 ± 10	0.0 ± 0.0	?	-
5	48	$B^0 \to \pi^0 K^{*0}(\to K^+\pi^-)$	0.0 ± 0.0	12.9 ± 7.4	-	
6	69	$B^0 \to K^+\pi^-$	1.2 ± 0.2	1.5 ± 0.2		
6	45	$B^0 \to \pi^- K^{*+}(\to K^+\pi^0)$	19.5 ± 11.2	11.5 ± 6.6		
9	86	$B^0 \to (K^{(**)}_X\pi)^0 \to K^+\pi^-\pi^0$	0.0 ± 0.0	36.5 ± 27.4		
9	-	$B^0 \to (K^{(**)}_X\pi)^0 \to$ other	28.7 ± 28.7	24.4 ± 24.4		
11	-	$B^0 \to (K^{(**)}_X\rho)^0 \to K^+\pi^-\pi^0 X$	0.4 ± 0.4	2.8 ± 2.8		
8	-	$B^0 \to$ charm	102 ± 23	13 ± 4		

Signal and background for ΔE and M_{es}



Test of B-backgrounds in ΔE sidebands



- in the nominal analysis we cut tight $-0.12 < \Delta E < 0.15\,\mathrm{GeV}/c^2$

-- most of the B-background peaks in the low values of ΔE

-- we extend our B-background and qq PDFs into negative ΔE sidebands and make sure it agrees with data

Cross-checks and systematics

- we a lot of cross checks where we fit samples of:
  - signal MC
  - signal MC+continuum
  - signal MC+B-background
  - signal MC+continuum+B-background

and make sure we get from fir what we put in

- to make sure fit setup is correct, we run hundreds of Toy experiments and check for biases

- for unknown branching ratios(4-body B-background) we vary in wide range the branching ratios(+100%,-50%) and study the associated systematics

-we used signal sample of $\rho\pi$ and ρK events, to fit for B-lifetime and ρK signal sample(self-tagging) to fit for the mixing frequency Δm

Yields and charge asymmetries

Preliminary

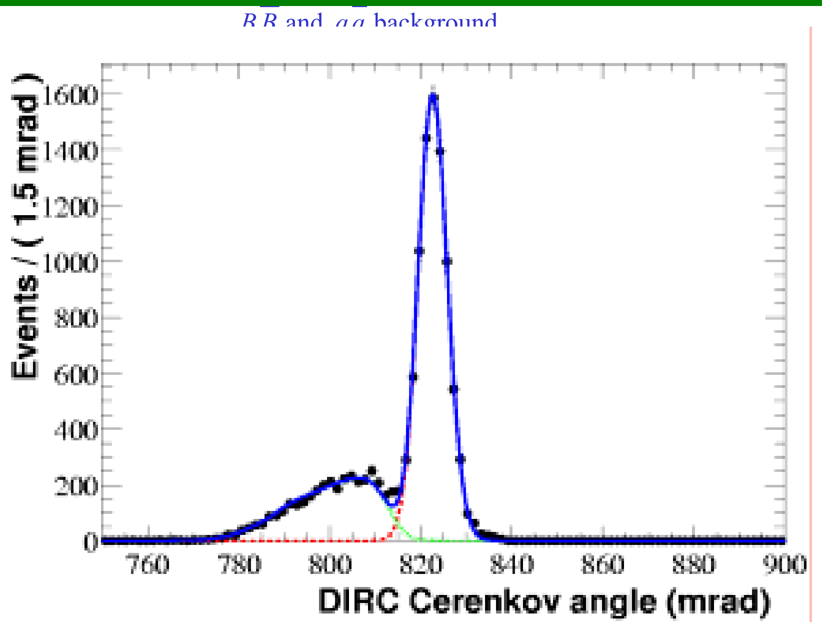
$$N_{\rho\pi} = 413\,^{+34}_{-33}$$

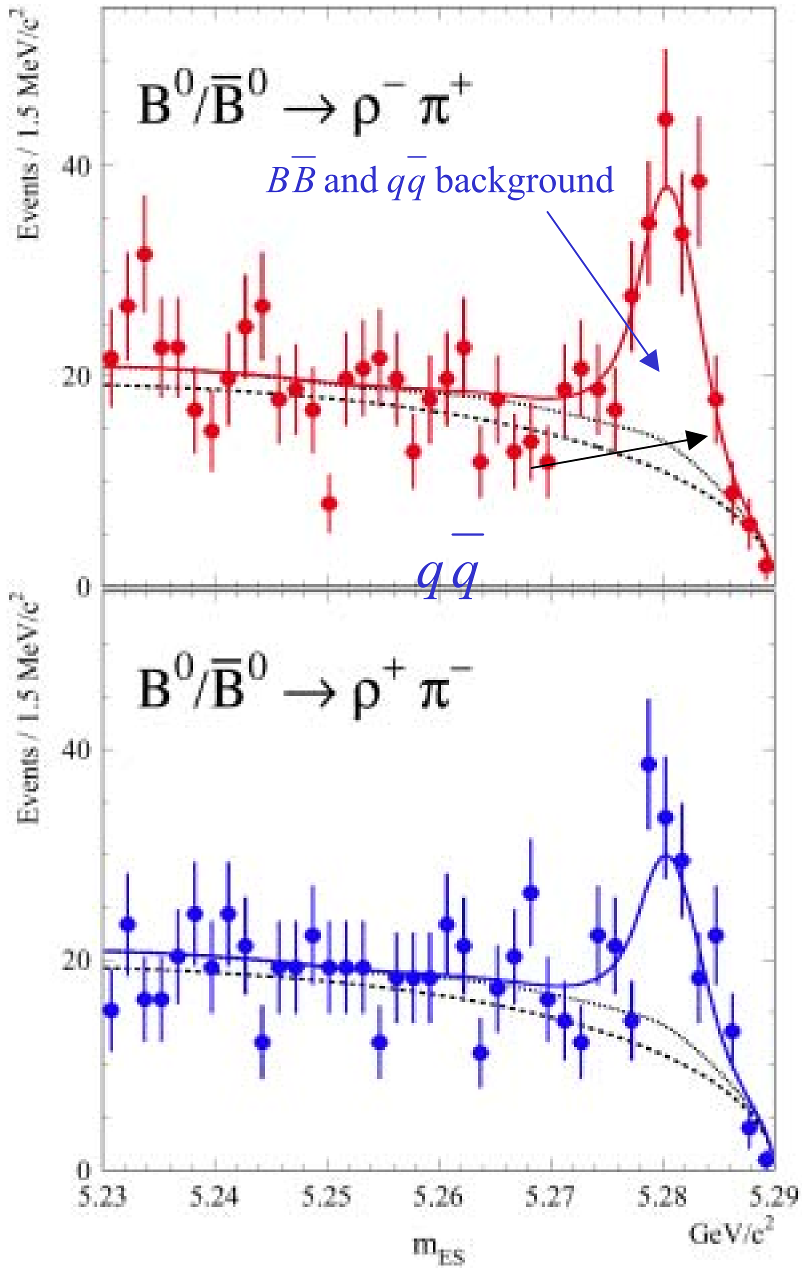
$$N_{\rho K} = 147\,^{+22}_{-21}$$

hep-ex/0207068

$$A_{CP}^{\rho\pi} = -0.22^{+0.08}_{-0.08}(stat) \pm 0.07(syst)$$

$$A_{CP}^{\rho K} = 0.19^{+0.14}_{-0.14}(stat) \pm 0.11(syst)$$





$B^0 \to \rho\pi$ time-dependent asymmetry

hep-ex/0207068

$$C_{\rho\pi} = 0.45^{+0.18}_{-0.19}(stat) \pm 0.09(syst)$$

$$S_{\rho\pi} = 0.16^{+0.25}_{-0.25}(stat) \pm 0.07(syst)$$

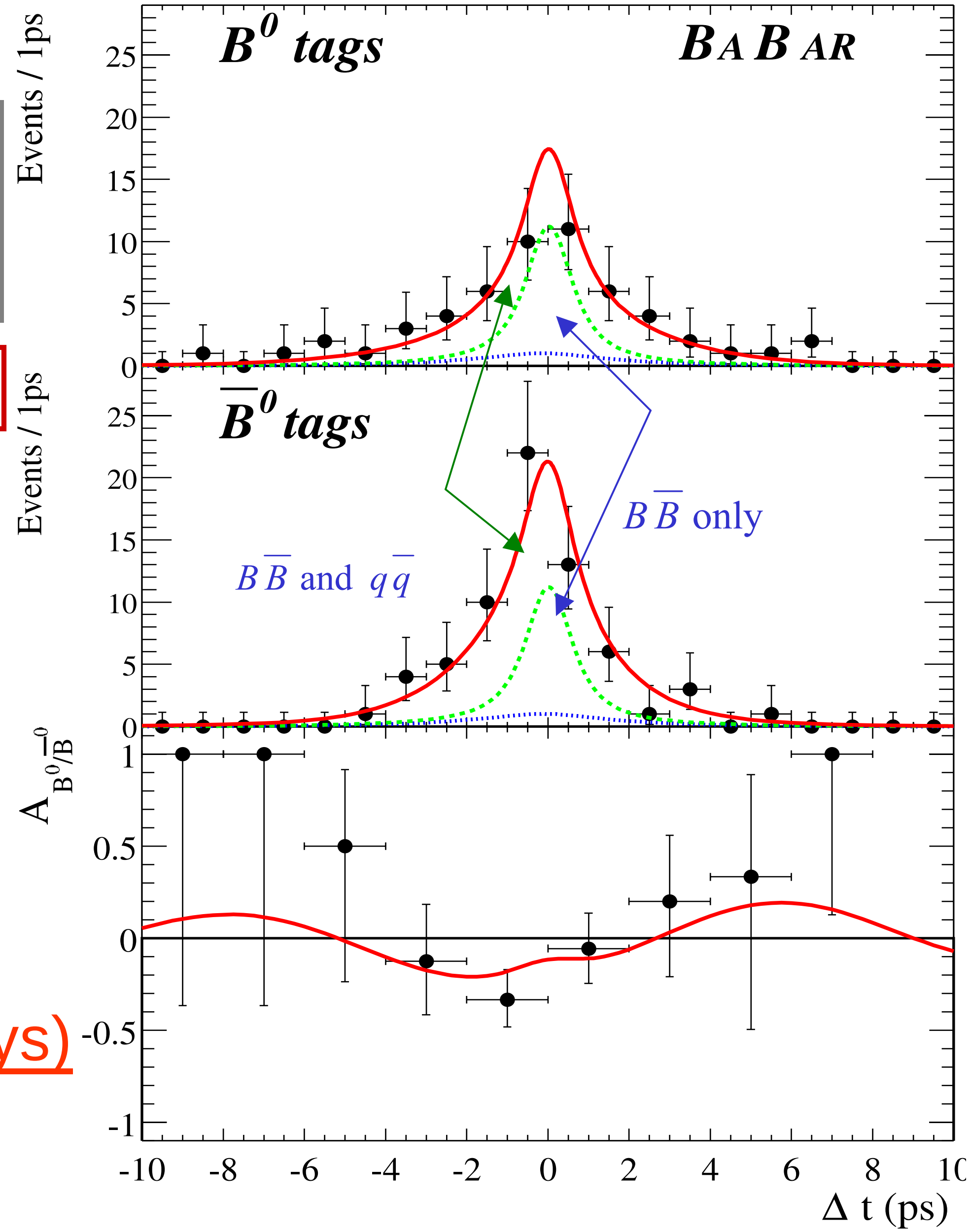
Preliminary

$$\Delta C_{\rho\pi} = 0.38^{+0.19}_{-0.20}(stat) \pm 0.11(syst)$$

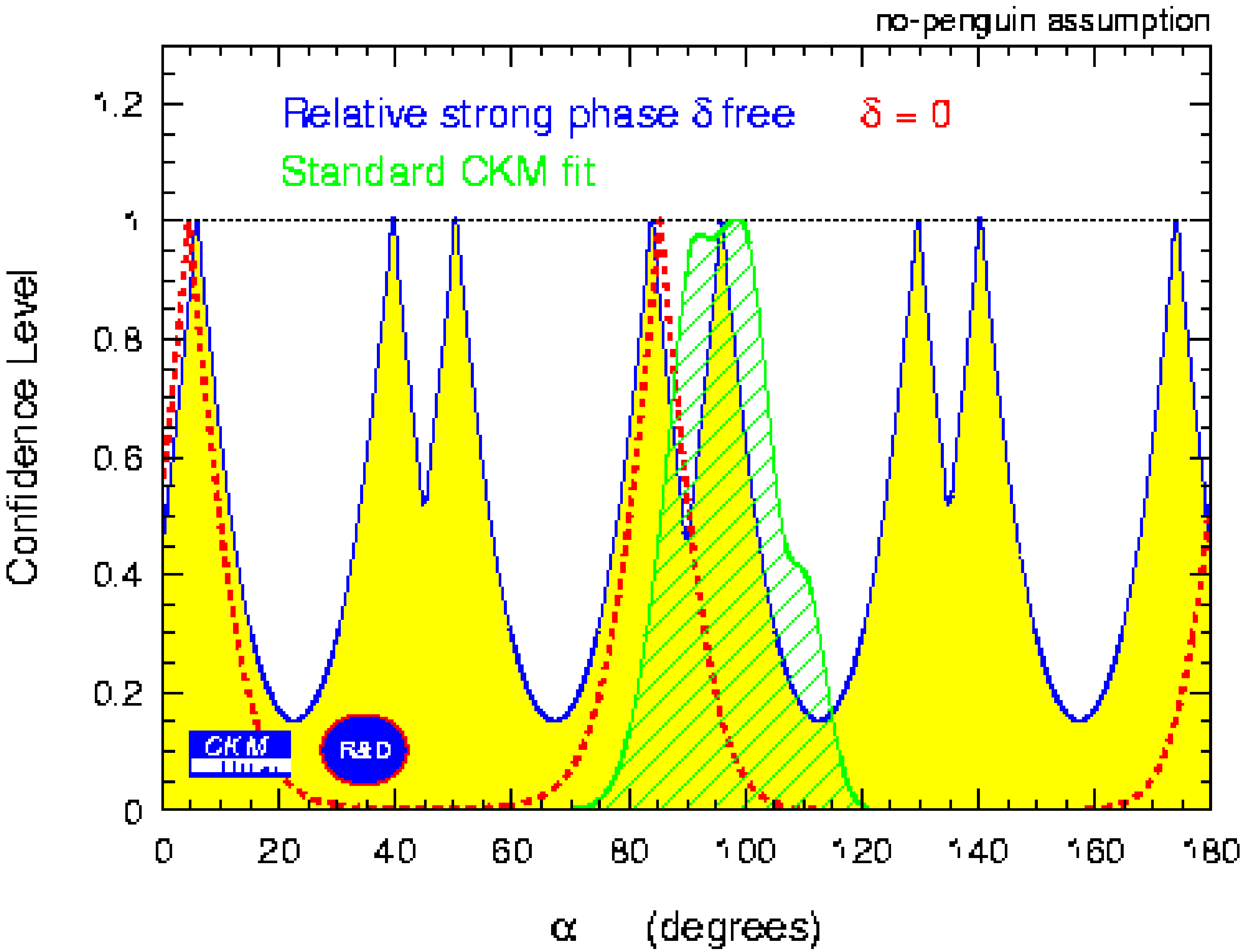
$$\Delta S_{\rho\pi} = 0.15^{+0.25}_{-0.25}(stat) \pm 0.05(syst)$$

Systematic error dominated by uncertainty on B backgrounds

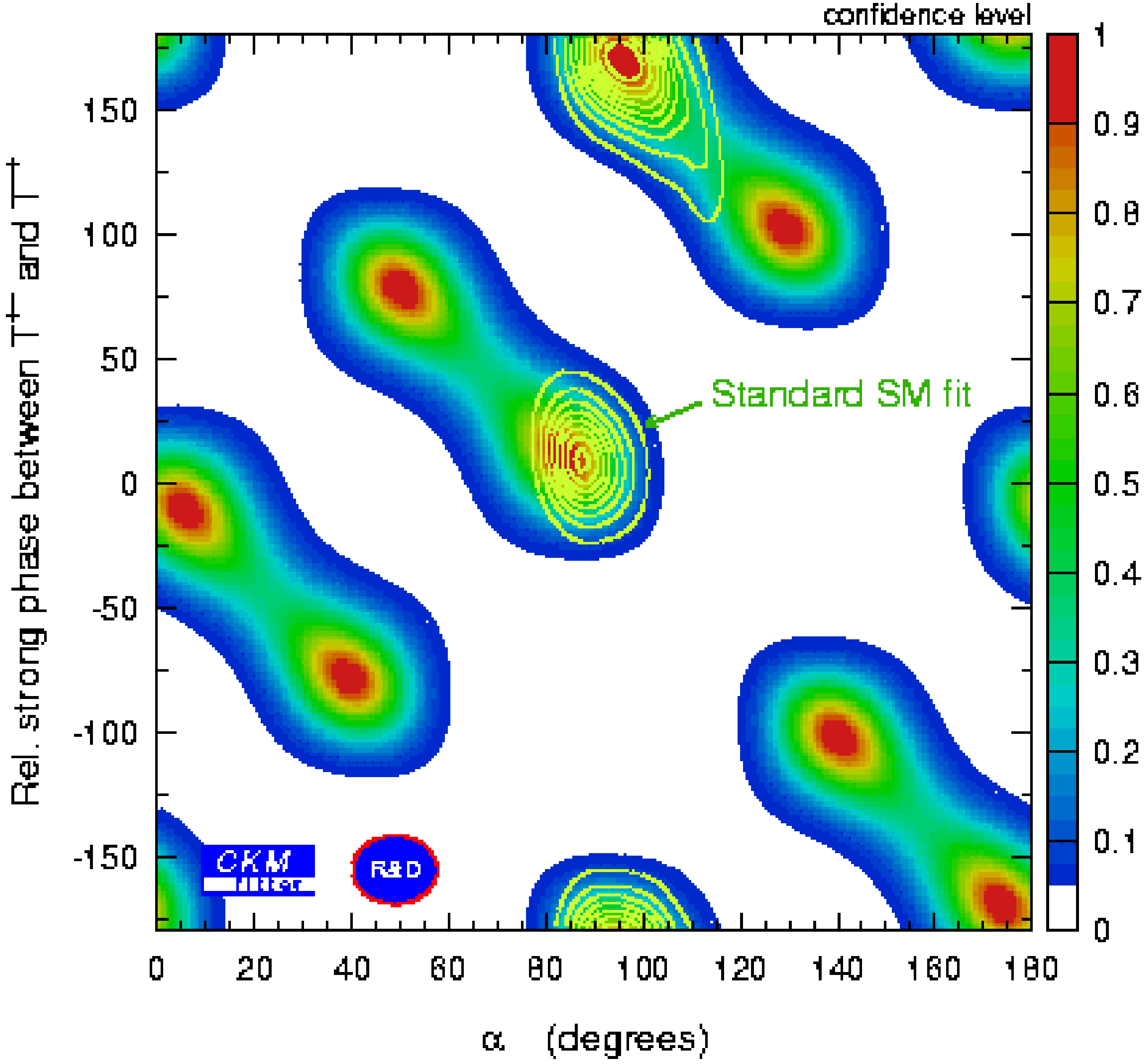
large value of C excludes Superweak Model at 3.1(2.5 sys) sigma level



Extraction of α(no penguins)

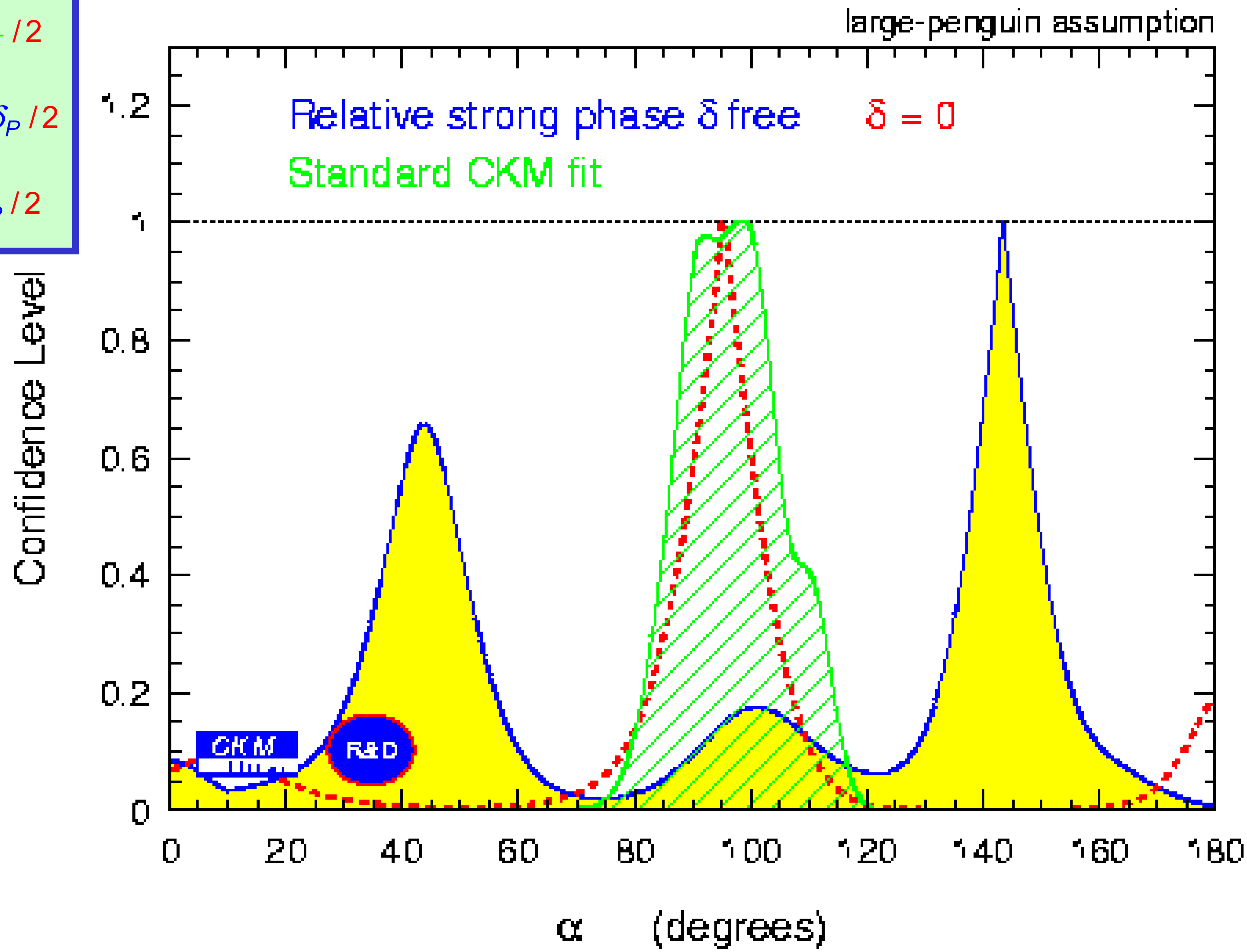


Extraction of α(no penguins)



Extraction of α(large penguins)

$$T^{+-} = 1.00 \times e^{i\delta_T/2}$$
$$T^{-+} = 0.47 \times e^{-i\delta_T/2}$$
$$P^{+-} = -0.09 \times e^{i\delta_P/2}$$
$$P^{-+} = 0.01 \times e^{-i\delta_P/2}$$



Conclusion

- program designed to measure “alpha” is well under way in BaBar

- disagreement between BaBar and Belle on C and S for $\pi^+\pi^-$ analysis remains puzzling

- in overall, the prospects for “alpha” using $B^0 \rightarrow \pi\pi$ don’t look too good…

- BaBar made first preliminary measurement of time-dependent CP asymmetries in $B^0 \rightarrow \rho^+\pi^- / K$, the final version of the analysis will be out soon(it would be interesting to see how Belle’s numbers look like)
- work towards Dalitz plot analysis is under way ($B^0 \rightarrow \rho^0\pi^0$,..)

- new CP modes are under consideration($B^0 \rightarrow \rho^+\rho^-$,..)